

# Chemical & Process Engineering

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## Topics of the Month

### Chemicals and food supplies

CHEMISTRY'S part in increasing home food supplies in Britain was given full credit by Dr. N. C. Wright, president of the Agriculture Section of the British Association at last month's meeting in Belfast. Referring to the substantial increases in agricultural output made possible by the use of fertilisers, he pointed out that nitrogen usage, which in 1939 stood as 60,000 tons p.a., increased threefold by 1944 and to 220,000 tons by 1950. Over the same periods the tonnages of phosphates, potash and lime showed parallel increases, being roughly doubled by 1944 and trebled by 1950. Moreover, not only were these fertilisers applied on an increasingly extensive scale, but during the war rationing and restrictions on their use tended to ensure their application to the best advantage.

Modern crop protection chemicals also powerfully stimulated agricultural expansion. The dressing of seed with fungicides had long been established practice and by 1950 no less than 80% of the country's wheat and 50% of other cereals were so treated. A new development in the ever-increasing practice of seed dressing was the use of chemicals which were active against wireworm as well as fungus growth. Still more striking was the growth in the use of weed-killers which are now applied as dusts or sprays to more than a quarter of Britain's cereal acreage. Animal production had also benefited from chemistry. Penicillin

treatment, for instance, had undoubtedly curtailed the losses from mastitis.

In contrast to this picture of the benefits conferred by chemistry on food production were the doubts about the use of chemicals in food expressed by Prof. Wardlaw, president of the Chemistry Section. Observing that the food processor has chemicals for every need—preservatives, emulsifiers, colouring agents, flavours, flour improvers, anti-staling and anti-rancidity agents, sweetening agents, anti-oxidants and antiseptics—he expressed the view that during the past decade most people had had an uneasy feeling that all was not well with their food and that 'between the scientist and the bureaucrat eating has lost much of its pleasure and nearly all of its taste.'

Some of Prof. Wardlaw's remarks, such as the addition of chalk to flour had caused a shortage of ceiling whitening, were taken from their context and given wide publicity. In fact, his argument was that the increasing use of chemicals was the result of the public's demand for a varied diet all the year round. 'A great industry has been created which guarantees a steady supply of fruits, vegetables and processed products and is founded on discoveries made in chemistry, biology and engineering. Moreover, there is every indication that large-scale preparation, processing and cooking of food will increase throughout the world.'

He supported the view of the Advisory Council on

Scientific Policy that, although the risk to health of the presence of toxic substances in consumer goods was probably small, the increasing demand for chemicals from the food industry made it necessary to expand the existing inadequate facilities for testing new substances before they were generally used.

In fact, the food and chemical industries are being far more responsible than the few widely publicised excerpts from Prof. Wardlaw's address might suggest, and it is a pity that the public were not given the complete picture, including the comments of Dr. Wright.

### Manufacture of algal chemicals

**M**ANNITOL and insoluble laminarin have been produced from seaweed on a pilot-plant scale at the Gulland laboratories of the Institute of Seaweed Research, Inveresk, Scotland. These, in amounts varying from  $\frac{1}{2}$  to 7 lb., were supplied to 17 firms who wanted them for market assessment. The processes used were essentially those developed in the laboratory and, apart from obvious modifications necessitated by the larger scale of operation, no attempt was made to work out techniques on which industrial scale operations could be based or which would allow accurate costs to be calculated. However, this small-scale production and the preliminary experiments to extract water-soluble laminarin and fucoidin have revealed points requiring further investigation in the laboratory methods. Such problems include reduction of extraction and precipitation times, determination of optimum screen size of milled weed for effective extraction without serious filtration difficulties, the efficacy of various counter-current extraction systems and the use of solvents other than methanol.

The Institute has also studied the isolation of fucoidin on a laboratory scale and evolved a technique for its extraction. Methods of purifying it have been investigated and a product containing more than 40% L-fucose on hydrolysis has been obtained. A method has also been worked out for the preparation of L-fucose in good yield from fucoidin. The common British brown algae have been evaluated as sources of alginic acid, and the effect of factors such as temperature of drying and conditions of extraction on the grade of alginate studied. Fundamental studies have been continued on alginic acid, fucoidin, laminarin, the algal proteins and the iodo compounds.

The Institute of Seaweed Research was originally formed in 1944 as the Scottish Seaweed Research Association. During its first two years it was mainly concerned with determining whether there was sufficient seaweed growing in Scottish waters to support an industry capable of bringing employment to the Outer Isles and Highland coastal areas. These investigations proved successful and a wider programme of research and development was formulated. As indicated in the Institute's recently issued annual report for 1951, a wide range of investigations is being carried out. Some work is being done on the utilisation of algal chemicals, but the finding of commercial outlets is in general being left to the interested industry.

### Drying of seaweed

**A**CHEMICAL engineering problem being studied by the Institute of Seaweed Research is the removal of water from seaweed. Studies of the various factors affecting thermal drying were continued at the Royal Technical College, Glasgow, using a modified through dryer. Although

the results have not yet been fully analysed, the indications are that increase in temperature, air velocity and agitation of the material during drying reduces drying time. Reducing the piece size has a similar effect, while increase in humidity and bed depth increases the drying time. The results of the tests on a large commercial scale Aldersley-Pehrson type drier have now been analysed. It was found technically suitable for drying fresh *Laminaria cloustoni* stipe or whole plant (after chopping) to a suitable condition for grinding. Drying whole plant gave a greater output than drying stipe or frond separately.

A short drying test using *Laminaria cloustoni* was conducted with a Templewood Mk. 2 drier, but it appeared that this type of drier was unsuitable for drying minced frond, largely because at the optimum thickness of bed its capacity is very low compared with the amount of fuel used.

Preliminary trials on a pilot scale rotary louver drier indicated that minced *Laminaria cloustoni* stipe can be dried satisfactorily, although no work has yet been done on the economics of drying in this machine.

Preliminary tests have been carried out also on the de-watering of seaweed by pressing in an experimental peat press and laboratory squeeze rolls, and by centrifuging in a Pott-Cassels centrifuge.

### Ethylene plant instrumentation

**A**S pointed out by Alan Pollard in his *CHEMICAL & PROCESS ENGINEERING* series on automatic control (July, August and September), it is the petroleum industry which is the most enthusiastic devotee of this form of process control. The elaborate systems now being developed by the industry are well illustrated by the new *Hypersorber* ethylene purification plant of the Dow Chemical Co. at Midland, U.S.A. The plant consists of two processing units, one above the other, the lower of which strips methane, ethane and ethylene from propane, propylene and heavier hydrocarbons, while the upper section separates the ethylene from methane. The adsorbing material used is activated carbon, and efficient operation depends upon its continual re-activation.

Graphic panels are employed in the *Hypersorber* control room because of the size, complexity and physical arrangement of the equipment, and because of the assistance of this type of layout in the training of plant operators. As many as 90 temperature, 30 flow and 30 pressure readings are transmitted to the panels from the process area, and among the unique instrumentation problems involved was that of the measurement of the flow and level of granular carbon. The flow of the carbon is measured by tachometer generators attached to rotary-type valves, with indicating tachometers on the graphic panels calibrated in carbon flow units, while the operation of the carbon level transmitters depends on the continuous downward flow of carbon against a vertical friction member suspended from a torque tube, which operates a conventional transmitting pneumatic pilot mechanism.

Three indicating-transmitting infra-red type gas analysers are also used to obtain plant efficiency information. The cracked gas, fuel gas and ethylene product gas streams are analysed, the analysers being equipped to standardise automatically against samples of known concentration. Finally, a three-point strip-chart instrument on the main panel receives and records these analyses, thus enabling full information to be presented over the operating efficiency of the plant.

### British enterprise needed in Labrador

THE formation of a new British company, made up of a number of existing companies, to develop the resources of Newfoundland, and more particularly of Labrador, was suggested by the Hon. Joseph Smallwood, Prime Minister of Newfoundland, who recently addressed a meeting in London, arranged by the Federation of British Industries, of firms and associations likely to be interested in such developments. The actual development of the resources believed to exist in Labrador, he said, must necessarily be preceded by a prospective or exploratory period.

Among the minerals known to exist there were vast quantities of iron ore, together with manganese, and also, there was every reason to suppose, titanium, copper, lead and zinc. There were unlimited quantities of high-grade timber, and a greater hydro-electric potential than was at present developed in all Canada. Mr. Smallwood emphasised that any company undertaking exploration of these minerals should proceed rapidly. 'Labrador,' he said, 'is the great remaining storehouse of natural wealth and natural resources of North America.'

Britain, said Mr. Smallwood, possessed the greatest experience and skill in developing remote, difficult and uninviting areas and they wanted Labrador to be developed by British companies. The cost would be stupendous.

Mr. Smallwood estimated that, if a new British company were formed to explore and develop the natural resources of Labrador, a capital of £2 million would be needed. By using British personnel and equipment, including British aircraft for the preliminary aerial survey, a relatively small part of the £2 million would have to be converted into dollars. Development, as distinct from prospecting, would have no time limit set to it, and the cost of development might be anything from \$20 million to \$100 million.

Mr. Smallwood described how, in the preparations for the development of the vast iron ore deposits in the west of Labrador (see *CHEMICAL & PROCESS ENGINEERING*, July, p. 360), the building of the railway to it had to be carried out by aerial survey and by flying in the necessary construction equipment. This year 19,000 tons of equipment had been flown in; bulldozers were packed in small parts and welded together on the spot. This 365-mile railway was being constructed at a cost of \$150 million.

In Newfoundland the population of 375,000 was now growing as rapidly as in any other province of Canada. Twelve companies, mostly American, were engaged in prospecting. Together they employed more men than had been employed during the whole of the past 50 years. Most of the prospecting was for minerals, including nickel, copper, zinc and lead. Drilling for oil was in progress on the west coast. Newfoundland's deposits of fluorspar were the richest in the world. A new asbestos mine was in production and a copper mine would be in production later this year. One of the two paper mills was the largest in the world with an output of 1,200 tons/day. A number of other industries that had started production or were about to do so included a machinery plant, a cement mill, a plasterboard factory, a plywood mill, a tannery for processing seal skins, a cotton textile mill, an oil-hardening hydrogenation plant and a rubber factory. **Although these branch factories had been established, not one British industrial company was among them, though there were some from the Continent of Europe.**

These facts make Labrador a challenge to British inventiveness and courage.

### More coke ovens for the steel industry

BRITAIN hopes to make 16 million tons of steel this year. To do this 10.5 million tons of pig iron will be needed, 1 million tons more than in 1951 owing to smaller supplies of scrap which this year may be 100,000 tons less than in 1951, when the supply was 9,140,000 tons. To provide this pig iron additional blast furnace capacity of 1.2 million tons p.a. will come into operation this year. This is in addition to the 700,000 tons of new pig iron capacity which has been provided since 1945. However, some of this total of nearly 2 million tons replaces smaller or less efficient units and the net gain in iron production is less, though sufficient for present needs.

Some of this increased capacity calls for more home-produced ore and some for imported. Domestic ironstone consumption is expected to reach between 16.5 and 16.75 million tons, expressed as raw stone. This means that more coke will be needed. On modern furnaces domestic ore with about 30% iron may need between 19 to 22 cwt. of coke/ton of pig iron, while imported ore with about 55% iron may need only 15 to 17 cwt./ton. The industry is thus taking steps to build new coke ovens to produce the coke needed for the new blast furnaces. In 1950 the industry used 6,650,000 tons of its own coke, the corresponding figure for 1951 was 7,086,600 tons and for this year it will increase to 8,065,000 tons. At the moment the industry produces approximately two-thirds of its coke requirements and buys one-third from outside sources. It requires an average of 76,000 tons/week of outside coke (the rate of deliveries in 1948) if the blast furnace needs are to be met in full. For some time these deliveries have only been running at the rate of 70,000 tons/week, and it is a matter of urgency that they are restored to this higher level in order to prevent any loss of pig iron through the shortage of coke. The industry's post-war plans provide for the building of new coke-making capacity to match the expansion in pig iron production so that the dependence on outside supplies of coke should not increase beyond the 1948 level of 76,000 tons/week.

### Ash, a brake on industrial efficiency

ASH has always adversely affected combustion processes using solid mineral fuels, but it has caused new difficulties as industrial techniques have been extended in the direction of larger boiler units and higher temperatures and pressures. Moreover, there is a tendency towards the production and marketing of coals having a higher ash content than formerly. Ash is not only a diluent of the coal substance, but it lowers boiler efficiency and increases freight and handling charges, together with repair and maintenance costs. It also reduces output, because modern combustion conditions have led to severe problems of fouling and corrosion, and it often causes considerable atmospheric pollution by grit.

During recent years much research has been directed towards the elimination or mitigation of these difficulties, and very considerable progress has been made. In order to review this progress and to promote further enquiry, the Institute of Fuel has sponsored a conference, to be held in London on October 28 and 29, on the effect of ash and clinker upon industrial processes, with special reference to steam raising. The subjects to be covered will include consideration of the occurrence and fundamental properties of ash, methods of sampling and analysis and the partial removal of ash from coal by cleaning processes. Problems of more



practical interest to the industrialist will then be dealt with, including the treatment and disposal of ash and clinker, the problems of deposits and corrosion and the influence of ash upon boiler design. The quantitative effect of ash upon boiler efficiency will also be considered and it is hoped to have an authoritative account of recent work carried out by the British Coal Utilisation Research Association in this field. Available methods of evaluating coals of varying ash content will be discussed as a matter of special interest in relation to the new price structure of the National Coal Board, which aims at making full allowance for all the effects of ash and at the same time providing sufficient incentive to induce consumers to burn high-ash coals. This problem is of great national importance in connection with the overall economic utilisation of our coal resources, and in their own interest consumers should be in a position to assist the N.C.B. in arriving at a final price structure which accurately reflects real values under industrial conditions. Methods of utilising high-ash coals will be discussed, and finally there will be several papers dealing with the effect of ash upon various industrial processes.

Present-day research covers such a wide field and is carried on by so many individuals and bodies that it is almost impossible for the ordinary man in industry to keep abreast of the results or to co-ordinate them so as to acquire a comprehensive knowledge of even a small field. There is inevitably a long delay before new knowledge can reach the textbooks, and it has been said that the lag in the practical application of the results of research work is such that there would be no immediate loss to industry if all such work were dropped for a period of, say, 10 years and all energies directed to the application of what is already known.

Periodic conferences to cover limited fields, such as this one, serve to provide a concise statement of the present state of knowledge in that field and to supplement it by discussion based on practical experience, much of which is not normally available beyond a very limited circle.

### Research expenditure analysis

THE latest survey of the Federation of British Industries shows an encouraging increase in industry's appreciation of the value of research. Just over 300 firms answered the Federation's questions about their research expenditure, and it was found that in 1950-51 these firms (301) spent £23,779,000 in this way, compared with the £21,815,000 spent by a larger sample (420) in 1945-46, when the last survey of this kind was made. It may justifiably be argued that a mere money figure is no satisfactory guide, since there has been a steady decline in the value of money during the past five years. This is conceded. However, that research is on the increase is shown additionally by the fact that in 254 firms out of the latest sample the number of qualified staff on research and development has risen by 52%.

The 301 firms employ 31,000 research and development workers. Of these, about 8,500 have degrees or equivalent qualifications. Chemists are still the most numerous among qualified staff, although the increase in their number (25%) has not been as remarkable as that of engineers (82%). The chemical firms themselves have almost doubled the number of engineers they employ; 429 in 1950 against 220 in 1946. There was also a rise of about 25% in the number of chemists employed; 2,221 against 1,778. Total of research and development staff employed by 64 chemical firms who co-operated in the survey was 10,705, of whom 3,168 were qualified. Turnover of these firms was £376,678,000 and

2.4% of this (£8,903,000) went on research and development. This was not as high as among scientific instrument firms (5.1%) or light electrical engineering (5.3%). The chemical firms' expenditure per unit of qualified staff was £2,810. The highest and lowest expenditures in this category were £4,674 (glass) and £2,068 (heavy electrical engineering).

Although the 42 research associations are not included in the survey, their expenditure in 1950-51 was £3.4 million, of which £2.15 million were contributed by industry. In 1945-46 there were 26 research associations and their expenditure was £1 million, of which £570,000 came from industry. Of the firms questioned by the F.B.I., 94 (31%) were members of one research association only, and 133 were members of two or more. These percentages are similar to those in the previous survey. Only 23 chemical firms did not belong to research organisations; 30 belonged to more than one.

There is a limit to the amount of direct comparison that can be made between this survey and its predecessor, because only 107 firms were common to both surveys. Of these, 18 were chemical firms. They have increased research and development expenditure from £1,795,000 p.a. to £3,640,000 and their total research staff has risen from 2,410 to 4,537, of which qualified staff was 1,215, compared with 792.

### Record year for Iraq oil industry

LAST year was one of intensive development for the Iraq Petroleum Co. and its associated companies. New records both of drilling footage and of oil production were established, but of greater significance was the expansion of the outlets for Iraq crude oil, the effects of which did not become apparent until 1952. Good progress was made with the new 30-in. pipeline from Kirkuk to Baniyas, which, now completed, adds another 14,000,000 tons p.a. to the deliveries of Iraq oil at the Mediterranean seaboard. Concurrently, production facilities at Kirkuk have been expanded to handle the increased throughput.

In the Bashrah Concession seven wells were completed bringing the number of producing wells in the Zubair field to 12. Pumping equipment for the 72-mile pipeline was installed and two loading jetties and eight 4,750,000-gal-storage tanks were completed at Fao. The first tanker loaded at this installation in December and sailed with a cargo of 11,000 tons of Zubair oil. By the end of the year 33,800 tons of crude oil had been exported from Fao and production from the Zubair field was running at a rate of 750,000 tons p.a.

During 1951, also, the Iraq Petroleum Co. and its associated companies operating in Iraq entered into a new relationship with Iraq by their offer in April to share equally with the Government of Iraq the profits from their operations in the country. Although not ready for ratification by the Iraq Parliament until February, 1952, the agreement, based on this offer, became operative with effect from January 1, 1951.

The effect of this new agreement with Iraq, combined with increased production resulting from the construction of the 30-in. pipeline from Kirkuk to Baniyas, and the inauguration of production from the Bashrah Concession, will result in greatly increased revenues for Iraq which, on the basis of present prices and costs, are expected to rise from £15,000,000 in 1951 to £59,000,000 in 1955. Under the Iraq Law of 1950 70% of these revenues will be devoted to capital schemes which will increase the productivity of the soil and enrich the lives of the people of Iraq.



# SAFETY

## Legal Obligations of the Chemical Engineer—I

By C. B. Roos, B.Sc., F.R.I.C.

(Formerly H.M. Deputy Superintending Inspector of Factories)

### Dangers of moving machinery

SECTIONS 12, 13 and 14 require that all prime movers (engines, motors, etc.), transmission machinery (belts, pulleys and shafting) and all dangerous parts of machines shall be 'securely fenced.' Although at first sight this may appear to be a problem for the works engineer, it is often the responsibility of the chemical engineer, especially in the 'design' or 'installation' stage of new plant. The only effective safeguard is complete enclosure of the dangerous parts. If safety by position is relied upon, e.g. for overhead shafting, or belts, pulleys and gears normally inaccessible, effective steps must be taken to ensure that no worker approaches the danger points while the machinery is in motion. Further, Section 16 requires that all guards must be constantly maintained in position while the parts required to be fenced are in motion or use. If it is necessary to remove guards frequently, e.g. for adjustment or lubrication of the machinery, it is sometimes advisable to 'interlock' the guard with the driving motor switch, so that removal of the guard automatically stops the machine.

### Scalding or corrosive liquids

Section 18 requires every fixed vessel, structure sump or pit, the edge of which is less than 3 ft. above the adjoining ground or platform, if it contains any scalding, corrosive or poisonous liquid, to be securely fenced to at least that height or to be securely covered. If fencing or covering are both impracticable, other steps must be taken to guard against people falling into the vessel, etc.

It is advisable that fencing should consist of toeboard and upper and lower rails. Gaps may be left for the passage of materials, but should be too narrow for a person to fall through. 'Other steps' will depend on circumstances. Where fencing 3 ft. high would be impracticable a low parapet 1 ft. high and 2 ft. wide would probably be acceptable.

Corrosive liquids such as strong acids are responsible for many accidents otherwise than by immersion, e.g. when being handled or by leakage from plant. Glass bottles should always be carried in baskets. Special tipping carriers for carboys can be purchased and should always be used. Cocks liable to leak should be shrouded with lead and provided with lead drip trays.

Scalding liquors also have their dangers. Boilers connected to a common blow-down

pipe must be fitted with cocks controlled by a key which can only be removed when the cock is on the closed position, and there should be only one such key in the boiler house. This is in fact a statutory requirement (Section 29 (3)). Before any vessel is entered all cocks should be locked in the closed position, or connections should be broken and blanked off.

### Safe means of access and safe place of employment

Many claims are based on the contention that Section 26 (1) of the Act, which requires an employer to provide and maintain safe means of access to any place at which any person has at any time to work, has not been observed. The chemical engineer will be well advised to ensure

In view of the large and increasing number of claims which are put forward every year by workers under the Industrial Injuries Act, it is important that chemical engineers should know their legal position. In this article the author deals with their responsibilities for the health and safety of workers in factories, and suggests methods for avoiding accidents and injury to health. When new plant is erected it is usually possible to incorporate safety measures in the plant design, but even with existing plant it is essential to take all necessary steps to render it safe. A claim for damages for injury arising from an accident or for an industrial disease contracted in the course of a worker's employment may be based on a breach of statutory duty by the employer or, where no statute is involved, on a breach of what is known as 'common law' duty. Briefly stated, the common law duty of an employer is that he must carry out his processes, or arrange his work, in such a manner as not to endanger the health, life or limb of his workers. A claim for damages based on a definite breach of statute is usually so clear-cut that, provided the breach can be proved in court, it stands every chance of success. A claim for breach of common law duty is based on what is known as 'case law,' i.e. on decisions which have been previously given in the courts and which are almost as binding as statutory requirements unless or until they are upset by later and contrary decisions. So far as factory employees are concerned the statutory requirements are covered almost entirely by the Factories Acts, 1937 and 1948, and by the various Codes of Regulations made under those Acts. It is obvious, however, that the requirements at common law are much more comprehensive than the statutory requirements and that many additional precautions are advisable apart from those definitely laid down by statute, if accidents and consequent claims are to be avoided. In the following pages the hazards and precautions have been arranged as far as possible in the order of the sections of the 1937 Act (which are quoted) relating to them, and additional safeguards to cover possible common law claims are also suggested. The Alkali Act, which is mostly concerned with the safety and health of the general public as distinct from the factory workers is outside the scope of the present article.

that valves, stop cocks and other control parts of the plant can be reached safely by workers who have to attend to them. This is usually a simple matter if it is tackled at the design stage, but not so easy in the case of existing plant. Any trouble or expense, however, is well worth while, as the courts take a very decided view of this section and interpret it on a very broad basis. It should be noted that the wording of the section is 'any person,' so that it does not refer only to persons employed by the factory occupier but includes contractors' men.

Subsection 2 of Section 26 deals with persons who have to work at heights of more than 10 ft. from the ground. Unless there is secure foothold and, where necessary, secure hand-hold, means must be provided, by fencing or otherwise, to ensure the safety of the worker. This requirement applies particularly to stagings and platforms which are common around chemical plant.

### Dangerous fumes

Accidents frequently occur when persons have to work inside confined spaces (tanks, vats, pipes, flues, etc.) in which dangerous fumes or gases may be present. Section 27 of the 1937 Act (as extended by Section 11 (3) of the 1948 Act) lays down a minimum size for manholes and requires (a) that all practicable steps shall be taken to remove any fumes which may be present and to prevent the ingress of fumes; (b) the maintenance of a positive supply of fresh air, e.g. from a blower; and (c) unless the space has been tested and certified to be free of dangerous fumes, the wearing of a safety belt and ropes. None of these precautions need be taken if the person inside is wearing a suitable breathing apparatus. 'Suitable' under these circumstances means an apparatus to which fresh air is supplied from an outside source. A self-contained canister-type respirator is of no use in a confined space.

### Inflammable or explosive dusts, gases and vapours

Section 28 (1) of the Act requires effective steps to be taken to prevent explosions which may occur in connection with any grinding, sieving or other process giving rise to dust. In certain concentrations many finely divided solids, particularly organic solids such as bone meal, starch, flour and cattle-cake form dangerous mixtures with air and a spark is sometimes sufficient to cause a violent explosion. These explosions usually start inside the grinding or other plant, but the really disastrous explosions occur when dust which has escaped from such plants is allowed to collect in workrooms. The primary explosion (often slight) which occurs inside the plant blows the outside dust into a cloud which is ignited and sweeps through the factory causing serious damage and frequently loss of life. The spread of an explosion and fire of this



[Photo: Siebe, Gorman & Co. Ltd.]  
Self-contained compressed air breathing apparatus for use in the chemical industry.

nature may be avoided by preventing any escape of dust from the plant, or if this is not possible by frequent removal of any dust which may have collected on walls, roofs, beams and fixtures.

It must be accepted, however, that, in any plant grinding inflammable materials in air, at some stage in the process conditions in the plant will be such that an explosion is possible. Section 28 (2) requires all practicable steps to be taken to restrict the spread and effects of any such explosion by the provision of chokes, baffles and vents or other equally effective means. Explosions frequently occur in the ducts used for carrying off the dust to a collector and the spread of flame can be arrested by using a rotary valve which keeps part of the duct always fully choked with dust. In an inclined worm conveyor a permanent dust choke can be secured by omitting one of the flights of the worm.

If an explosion occurs in a plant it will generally burst at its weakest point, so that certain specially weak points should be provided in positions where, if an explosion takes place, the issuing flame and burning material cannot do any harm. An early type of 'explosion relief' consisted of a panel of lead foil 0.005 in. thick, supported by 1-in. mesh wire netting, but recent investigation has shown that a hinged flap is better than a bursting panel. A further development consists of a combination of bursting panel and hinged door. Much of the work on explosion reliefs has been done by the Safety in Mines Research Board, from where detailed information can be obtained.

A statutory requirement of special importance to chemical engineers is Section 28 (3). This refers to plant which contains any explosive or inflammable gas or vapour under pressure greater than atmospheric pressure. Before the fastening of any joint

of any pipe connected with the plant, or the fastening of the cover, is loosened the flow of the gas or vapour into the pipe or part of the plant must be effectively stopped, e.g. by a stop-valve. It further requires that before any such fastening is removed all practicable steps shall be taken to reduce the pressure inside the plant to atmospheric pressure; and that if any such fastening has been loosened or removed no explosive or inflammable gas or vapour shall be allowed to enter the pipe or part of the plant until the fastening has been secured or the cover securely replaced.

Many serious explosions occur when tanks or other closed vessels which have contained explosive or inflammable substances, e.g. petrol and benzole, are subjected to heat in welding, brazing, soldering or cutting operations. Section 28 (4) requires that all practicable steps shall be taken to remove the substance or any fumes arising therefrom. The only reliable method of carrying out this requirement is by thorough steaming and ventilation. Experience shows that filling with water and emptying is not a satisfactory method. The vessel, of course, must be isolated from other sources of inflammable materials before heat is applied.

### Storage of inflammable liquids

A licence from the local authority is required for the storage of certain inflammable liquids and it is advisable to consult them before starting to do so. Certain general precautions against fire and explosion are essential, especially in view of the readiness with which such liquids escape from damaged or leaking vessels and the readiness with which they give off inflammable vapours and form explosive mixtures with air. All vessels should either be below ground level or surrounded by a mound of sufficient capacity to retain the whole contents of the vessel. Tanks otherwise closed should be fitted with breather pipes, with the open ends well away from sources of ignition, and with gauze fitted at the ends of the pipes. If liquid is pumped up to overhead tanks there should be an overflow return pipe to the lower tank so that the overhead tank cannot be overfilled. The overhead tank should also have a drain pipe, which can be opened from a distance, so that the contents may be run off to a safe place in case of fire near the tank.

### Pressure vessels

Boilers, steam receivers, steam containers and air receivers are dealt with in Sections 29-32. The most important requirement is periodic examination and report by a 'competent person,' who is normally the inspecting engineer of an insurance company. These inspectors are fully alive to all the legal requirements and always point out any breaches of the law in their reports. Provided their recommendations are carried out, therefore,

there need be no fear that the provisions of the Act are not being observed.

### Electrical apparatus

The dangers of electrical apparatus are two-fold: danger of shock or electrical burns; and danger of fire or explosion from sparks or hot electrical filament in an explosive or inflammable atmosphere. Both these hazards are covered by the provisions of the Electricity Regulations, but it is mainly the fire and explosion hazard with which the chemical engineer is concerned. Regulation 27 requires all conductors and apparatus exposed to inflammable or explosive atmosphere to be so constructed or protected and such special precautions to be taken as to prevent danger. The usual precaution is the use of special 'flame-proof' apparatus and the Safety in Mines Testing Station, Buxton, issues certificates ('Buxton Certificates') for apparatus that passes the test successfully. Explosive mixtures are not all equal in the severity of the explosion they produce and for this reason apparatus is classified in four grades:

- (1) Safe for methane.
- (2) Safe for propane, butane and the vapours of most organic solvents.
- (3) Safe for coal gas containing not more than 60% hydrogen.
- (4) Safe for hydrogen, acetylene and carbon bisulphide. Very little apparatus has been certified in this group.

It is essential that apparatus shall not be of a class lower than that of the gas for which it is to be used.

Apparatus of any of the 'flame-proof' classes may be considered safe where the risk is from inflammable dust, provided that the joints are sealed with paint or thick grease.

### Static electricity

Sparks from static electricity are capable of igniting gas mixtures and inflammable dust clouds. The following are examples of materials which can generate sparks due to static electricity: belts running on pulleys; dust issuing from a nozzle; benzole running through a pipe or issuing from a nozzle; and gas escaping from storage cylinders.

The only complete safeguard is to maintain the air of the room in a highly humid condition, e.g. by water running from fine jets or steam trickling steadily from a steam pipe. In addition, it is advisable for the whole of the plant to be effectively earthed. So far as belts and pulleys are concerned; the shaft should be earthed by brushes and earth wires and the belt by earthed metal combs. Better still, a conducting belt can be used, e.g. one made of anti-static belting.

### Specially dangerous materials

This applies to the manufacture and use of metal powders (magnesium and aluminium), metal soap powders, azo and nitro compounds, peroxides, etc. In such



[Photo: Holophane Ltd.]

Flameproof pendant lighting unit which carries Buxton Group Certificates, Groups II and III. Accurate light control by means of scientifically designed optical systems embodying internal and external prismatic glassware is claimed to be a feature of these robust units which provide wide lateral distribution suitable for restricted mounting heights and for the efficient illumination of vertical surfaces. The cast silicon-aluminium bodies are of substantial construction with all corners carefully rounded and the glass has a smooth external surface. The fittings are designed for use with 150-200 w. filament lamps.

cases the plant should be divided into small isolated units to prevent the spread of explosion. Each individual unit should be enclosed in blast-proof walls and both plant and enclosure be provided with explosion reliefs. The door of the enclosure should be interlocked with the motor driving the plant so that it cannot be started while the door is open, and so that opening the door will stop the motor.

### Health requirements of the Factories Acts

These are many and various and cover a large range of subjects so that only those which specially concern the chemical engineer are mentioned below.

**Lighting.** Section 5 requires efficient provision to be made for suitable lighting, whether natural or artificial, in any part of a factory in which persons are working or passing. The Factories (Standards of Lighting) Regulations, 1941, prescribe a standard of lighting for factories in which persons are employed for more than 48 hr. weekly, or in shifts, and these regulations will repay careful study by the chemical engineer. Although their application is restricted, they serve as a standard for common law purposes, and failure to provide lighting up to the standard of the regulations, although not a breach of statute, might well be the basis of a common law claim that there was a 'bad system of work.'

**Ventilation.** This subject is covered by Sections 4 and 47. Section 4 deals with general ventilation and requires suitable provision to be made for securing and maintaining, by the circulation of fresh air, the adequate ventilation of each workroom and for rendering harmless all fumes, dust or other impurities that may be injurious to health generated in the course of any process or work carried on in the factory. Under this section, therefore, it is necessary to provide properly placed inlets for fresh air and when such inlets are used in cold weather it will be necessary to provide means of warming the incoming fresh air. This may be done in several ways, e.g. by the use of properly designed openings so that the air is directed upwards towards the ceiling and does not impinge directly on the workers; by providing heating units near the fresh air openings; or by what is, of course, the best (but costliest) method, the installation of a plenum air-conditioning plant.

It will be realised that it is often impossible to render harmless by general ventilation the fumes, dust and other impurities given off in a workroom process and Section 47 will then be applicable. Under this section, where in connection with any process there is given off any dust, fume or other impurity of such a character and to such extent as to be likely to be injurious or offensive to any person employed, or any substantial quantity of dust of any kind, all practicable measures must be taken to protect the persons employed against inhalation of the dust, etc., and to prevent its accumulation in any workroom. The section further requires exhaust appliances to be provided as near as possible to the point of origin of the impurity so as to prevent its entering the air of any workroom.

The 'practicable measures' will vary according to the process and the nature of the impurities given off. It is possible in some cases to prevent, or at any rate noticeably lessen, the amount of impurity given off from a particular plant. Escape of dust can often be prevented by damping with a water spray. The use of enclosed leak-proof plant; the working of the plant at reduced pressure; the use of a specific device, e.g. a jet of steam above the poke-hole of a gas producer to prevent the escape of carbon monoxide—all these are examples which are actually found in many works. If the escape of impurity cannot be prevented, the very old and simple device used by the chemist in the laboratory and known as the 'fume cupboard' can still be regarded at any rate as the prototype on which to base a means of complying with the requirements. The principle, of course, is simple and well known: the plant giving rise to the impurity is inside the 'cupboard,' and the worker outside. The 'cupboard' may be small, or may be a large enclosure. The openings should be as small as practicable and the cupboard should be provided with an exhaust fan or, if the fumes



are corrosive, with a steam ejector. Provided there are no eddies or other special circumstances, an inlet air velocity of 100 ft./min. over all openings will prevent any escape of fume or other impurity.

In the opinion of many ventilation experts the use of the 'fume cupboard principle' is the most effective way of dealing with escape of dust, fume or other impurity. A less efficient, though unfortunately more common, method is the provision of a hood and duct leading to an exhaust fan. If this method is adopted a much higher air velocity is essential, but even with a powerful, high-speed fan there are many processes where it is almost impossible to effect complete removal of the impurity by this method. Fortunately this is now being more generally recognised and in one case at least the 'fume cupboard principle' has been applied to the removal of dust from dry grinding operations. Swing grinders used for grinding large castings have hitherto presented a difficult problem, but in several recent installations the grinders have been placed in an enclosure open only at the front, with a powerful exhaust draught at the back which draws the dust well away from the operator.



[Photo: James North & Sons Ltd.]

New 'Ribgrip' PVC gloves, heavily ribbed across the palm and fingers with solid PVC. They are claimed to be resistant to many chemicals and flameproof, besides wearing longer than rubber or leather.

The disposal of dust and fume needs a certain amount of careful planning. The section requires that the impurities do not enter the air of any workroom. In the case of a 'self-contained' (filter) exhaust unit where the collector is in the room, usually close to the machine, it must be enclosed and the enclosure provided with a vent pipe to the outside air. The Alkali Acts require certain poisonous gases to be rendered harmless before going to atmosphere. In the case of relatively harmless dusts and fumes the local authority may take action because a 'nuisance' has been created. It may also pay, in some cases, e.g. in processes giving rise to lead dust, to recover the material carried away by the exhaust draught.

In the second part of the article the following subjects will be discussed: special regulations under the Factories Act which affect chemical engineers; industrial diseases such as silicosis, dermatitis, lead and mercury poisoning; the Industrial Injuries Act; recent legislation affecting Common Law liability, including the abolition of the doctrine of common employment.

## Conference on Chemical Works Safety

Improved working conditions have reduced considerably the accident rate in many chemical works. There is still room for improvement, however, and to learn about the best modern safety techniques about 200 chemical executives from the U.K., Australia, France, Germany, Holland and Sweden attended the fourth Chemical Works Safety Conference organised by the Association of British Chemical Plant Manufacturers. Mr. J. Davidson Pratt, director of the Association, was in the chair. Here are summaries of the five papers presented.\* They deal with plant and laboratory safety, toxic dusts, explosion relief, plant maintenance and transport and storage of chemicals.

### Plant maintenance

C. A. BEATON, chief engineer, Monsanto Chemicals Ltd., discussed safety in plant maintenance under two broad headings, firstly, safe design, erection and maintenance of plant and secondly, the formulation of safety rules and regulations and methods of enforcing them.

Safety as well as ease of maintenance should be constantly borne in mind at every stage in the development of a project. Day-to-day plant maintenance work involves the carrying out of many tasks in an atmosphere surrounded by hazards of both a chemical and mechanical nature. Because the engineering worker in a chemical works is being considered here it follows that the chemical hazard is the greatest source of danger, particularly so to the skilled man, who has most probably received his initial training as a craftsman in an engineering works, where chemical hazards may have been totally absent.

The engineering worker must be made fully aware of the new conditions under which he is expected to work and he must be physically equipped for the tasks he will have to carry out.

There are several methods of striving for ideal safe working conditions. At

Monsanto, all ladders are constructed in accordance with the best practice and periodically inspected. So are all lifting appliances, scaffolding and electrical equipment. Adequate liaison exists between the engineering and chemical staffs, safety officer and fire prevention staff. Work must be planned so that the maintenance worker knows exactly how to tackle the job. There must always be sufficient equipment to protect the maintenance worker against contamination by chemicals and the equipment must be of the correct type to give maximum protection, comfort and freedom. The worker must be told how and when to use the equipment to the best advantage and refresher courses for skilled workers are advisable. Suggestion schemes are also advantageous and ideas should be rewarded. Occasionally dangerous practices are reported by the workmen themselves or by the safety officer, and at Monsanto they are immediately studied and the remedy applied as speedily as possible. 'No Smoking' is rigidly enforced throughout the factory, even in the power station,

and violation by anyone is followed by instant dismissal of the culprit.

Maintenance supervisory staff must have a thorough grounding in recognising the varied chemical hazards within the works, and must be familiar with the various manufacturing sections. Wherever possible, the supervisor must be able to select the right man for the right job. Even in highly-skilled craftsmen, temperament and adaptability vary considerably and if the more difficult jobs are to be carried out safely and successfully, the right man must be selected.

Mr. Beaton concluded by discussing at length various aspects of safety in plant maintenance. These included sections on chemical hazards such as tank entry, toxic gas tests, use of flames, welding apparatus, etc., general precautions in opening and repairing pipelines, electrostatic risks, pressure vessel examination, thickness gauges, relief valves and safety devices and the main joints on pressure vessels as well as a discussion on the mechanical hazards.

### Toxic dusts

Exposure to dusts in industry can produce four distinct types of disability, namely, the pneumoconioses, toxic effects,

\*Extracted from the *Proceedings of the Fourth Chemical Works Safety Conference, 1952*, published by the Association of British Chemical Plant Manufacturers. Pp. 193. 7s. 6d. post free.

metal fume fever and an allergic reaction. J. S. Evans, Technical Department, Federation of British Industries, dealt briefly with the effects of inhaled dusts and the measurement of dust. Prevention being better than cure, the control of dust is an important factor which has to be considered at an early design in the design of a chemical plant.

If a toxic dust or fume exists in a particular process, then the first step should be to search for a non-toxic substitute. The substitution of alumina powder for silica flour in certain processes in the pottery industry and the substitution of bonded alumina abrasive wheels for sandstone grindstones in the metal industries have been important steps in reducing risk of injury to health in these industries. There is considerable scope for reducing the risk to health in the chemical industry by the substitution of non-toxic substances for many at present in use.

The obvious, though not always practicable, method is the total enclosure of the process giving rise to dust and keeping the enclosure under negative pressure so that dust does not escape from the enclosure. This method, however, is not generally practicable as workers have to have access to parts of plant to carry out operations in connection with the process.

In such cases the plant should be enclosed as far as possible and an effective exhaust draught provided so that no dust escapes from the openings necessarily left for access. To obtain the maximum air velocity to convey the dust the openings should be as small as possible and should be kept closed when not in actual use. The adaptation of the fume cupboard to processes giving rise to dust is the most practicable and effective way of dealing with such processes. Where a complete fume cupboard cannot be provided for a dusty process, then an exhaust hood and duct must be used. The hood must be designed and placed to give the maximum airflow from the zone of dust production and to prevent the escape of dust into the workroom. Exhaust hoods which allow a workman to place his head between the source of dust and the exhaust are not unknown in industry.

The dust arising from the grinding of metal castings is, of course, highly dangerous, as the sand adhering to castings is in a finely divided state and this is dispersed in the atmosphere during grinding.

Wet methods may be effective in suppressing many dusts. However, each method requires careful investigation before deciding on its effectiveness. For instance, in one process where metals were cleaned by blasting with a slurry of silica flour and water, it was found that the wet method was quite ineffective. In asbestos spraying, however, it has been established that suitable predamping together with effective spraying during application almost reduces the concentration of free airborne asbestos below the dangerous limit.

The greatest proportion of industrial dust must be removed by exhaust methods and many industries are faced with the disposal of this dust. It may not be disposed of to the atmosphere outside the factory so as to constitute a nuisance or to be prejudicial to the health of the neighbourhood. The methods of dust collection and disposal will depend on the size range and the concentration. Cyclones, multi-cyclones and bag filters are effective for coarser dusts. For finer dusts below  $3\ \mu$  of a highly toxic character effective collection can only be ensured by the use of electrostatic precipitators.

### Dust explosion relief

It has long been recognised in industry that there are certain processes in which, by some mischance, pressures may be developed of such magnitude and at such a rate that no ordinary safety valve could cope with them. The pressure developed by an explosion in the plant is an extreme example. To relieve these pressures the plant engineer has had to turn to other devices, which can cope with a very sudden expansion of gas and relieve a very large volume of gas in a very short time. The devices that have been used are either bursting panels or relief doors.

Dr. D. Matheson, Factory Department, Ministry of Labour and National Service, discussed the relation between plant strength and dust explosion relief. The plant associated with the processes, in which dust explosion risks arise, is often of the lightest construction, and explosion reliefs, to be effective, have to be capable of preventing the pressure anywhere in the plant from rising to more than 1 or 2 p.s.i. These are the conditions that form the background of much of the research into explosion reliefs for dust plant. The first work for this purpose was carried out with open vents. Tests were made to determine how large the vent would have to be to ensure these low pressures.

Plant used for the grinding and processing of inflammable dusts is seldom designed with any idea that it should withstand pressure. In factories there are large units of such plant in which there are possibilities of high pressures. The situation and operation of the plant restricts the choice of position for explosion reliefs, and it is frequently impossible to fit vents at points where investigation has shown that they would be most effective in reducing the pressure. Much of this plant has to be installed inside a building and must therefore be provided with relief ducts which reduce the effectiveness of the vents. On such plant it is often a statutory obligation to provide vents, but it may be impossible to suggest a practicable type of vent that has any chance of preventing the bursting of the plant. One cannot fail to be impressed with the relative ease with which a solution was found for the more heavily built pressure plant, and it seems that, in spite of the best efforts of the research

workers, a satisfactory solution will not be found until it becomes the practice to construct stronger plant for the processes in question.

It should be mentioned, however, that some of the more advanced engineers in provender, chemical and other industries have recognised this. They are deliberately designing the plant and arranging the process to ensure that the plant will not burst inside an occupied room; but this practice is altogether exceptional.

It may be difficult to appreciate why so much concern is expressed over the possibility that plant may burst under comparatively low pressure. Severe injuries and fatalities have been caused by the direct effect of an explosion in the plant. It is well known, however, that, when plant bursts under a primary dust explosion, the shock and flame associated with this explosion frequently gives rise to a secondary explosion in the workroom outside the plant. The worst disasters have been caused by this secondary explosion, when the workpeople have been overwhelmed by burning dust.

### Laboratory and plant safety

Laboratory and plant hazards and the necessary precautions were dealt with by Dr. L. J. Burrage, Imperial Chemical Industries Ltd. He stressed that success depends on interesting and educating everyone in safety principles. The mere issuing of safety instructions and regulations is not sufficient; a discussion on the subject is of much more fundamental interest. All departmental heads and section leaders should foster this interest and take a personal interest in all those who work for them. The safety officer should be an enthusiast for his job and make it a hobby for which he is paid. If he is on the works staff then it is preferable for him to have an engineering background, but in a research department his background should be a chemical one.

In the laboratory it is the so-called minor accidents, mainly avoidable by taking simple precautions, which cause most trouble. They can be largely eliminated by all members of the staff taking a real interest in safety and good house-keeping, cleanliness and orderliness.

In plant scale operations, the precautions for apparatus protection are similar to those used in the laboratory, but in addition a number of devices and procedures are necessary that do not come into normal laboratory work. For instance, there is a difference of opinion as to the colour that guards should be painted. Some believe that guards are an integral part of the plant and thus should be painted the same colour. Dr. Burrage disagreed with this because when the guard is out of position, it is not obvious that it is a piece of safety equipment.

In the very early stages in the design of new plants, plans should be discussed with the safety department long before they are

(Concluded on page 546)

# Clad Steel Plate for Chemical Plant

By Heinrich Canzler, Dipl.Ing.

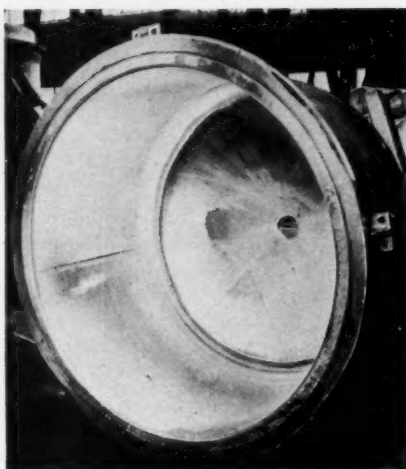
(Carl Canzler, Düren, Germany)

Clad, lined and plated metals have been used for corrosion-resisting chemical plant for many years. In each case, one metal is generally chosen for its corrosion-resisting properties and the other for its mechanical strength. By definition,<sup>1</sup> a clad steel plate is a composite plate made up of a commercial grade steel plate, to one or both sides of which there is, uniformly and permanently joined, a veneer or cladding of a corrosion- or heat-resisting metal, the thickness of which is an essential proportion of the total plate thickness. In view of the world shortage and high price of stainless steel, nickel and high-alloy metals, the manufacture of chemical plant in clad metal is of increasing economic importance. Below is a description\* of the production of clad steel plate by hot rolling, together with chemical engineering design data.

CLAD metal plate for chemical plant is produced either by compound casting or hot rolling. In the U.S.A., manufacturers generally prefer the compound casting cladding process, whereas in Germany preference is given to the hot rolling process. This latter process consists of simultaneously subjecting plate of the basis metal and cladding metal to a high temperature without admitting air and subsequently rolling them at a definite pressure into a single plate. In so doing, the respective metals are bonded into intimate contact whereby, on the one hand, a comparatively thin diffusion zone is produced at the boundary planes and, on the other, the layers are intimately joined throughout. Before rolling the ingot steel and cladding material into clad plate, they are mechanically worked in order to produce a dense, homogeneous structure. During the cladding operation, the material is again thoroughly worked by the action of the rolls.

Extensive tests have shown that the proportionate thicknesses of the original sheet metal are maintained in the finished clad plate. At first sight this seems surprising, because there is a tendency to believe that when using, for instance, copper, which is a comparatively soft metal, it will flow more than the basis metal which will have a comparatively greater resistance

\*Paper read at the Fourth International Mechanical Engineering Congress, Sweden, June 1952.



Silver clad steel vessel for the pharmaceutical industry.

to deformation. Actual behaviour leads to the conclusion that the metal is caused to seal during the first few passes. The resultant bonding of the two metal surfaces produces such a joint that in passing through the rolls none of the layers creep or flow. By this method a West German steel plant produces clad plate in sizes varying between 4,000 mm. (13 ft.) wide and 10,000 mm. (33 ft.) maximum length (in the latter case, however, the width is smaller) and weighing as much as 6,000 kg. (13,230 lb.) per plate. Semi-finished pro-

ducts such as covers, bottoms or ends of any shape, hemispheres, etc., are being produced at this plant from clad steel plate. The total thickness of the clad plate can vary between 4 mm. ( $\frac{3}{16}$  in.) and 70 mm. (2 $\frac{3}{4}$  in.). It is supplied with the cladding surface ground to a bright finish but it can also be polished when so required.

## Basis and cladding metals

The basis metal generally used is steel of boiler steel quality with a tensile strength of 36 to 44 kg./sq.mm. (51,200 to 62,600 lb./sq.in.). However, other boiler plate qualities or special steels are also satisfactory, e.g. high-temperature steels, non-age-hardened steels or other alloy steel.

The following metals are used for cladding: copper, nickel, copper-nickel alloys including Monel metal, silver, and a wide variety of corrosion- and heat-resisting steels.

The thickness of the cladding can be proportioned to meet any desired percentage of the total plate thickness. As a rule, it varies from 10 to 20% of the total thickness. The actual thickness of the cladding metal generally varies between 0.5 mm. (0.0197 in.) and 5 mm. ( $\frac{3}{16}$  in.). Also available is plant in double clad steel plate which, moreover, can have different cladding materials on each side.

## Physical properties of clad plates

Tests of tensile strength have shown

Table I. Tensile Strengths of Cladding, Basis Metal and Clad Plate

Cladding material	Total thickness of plate	Cladding		Temperature applied	A			B			C		D	
		Thick-ness	Proportional thick-ness		Clad plate=basis metal together with cladding			Basis metal without cladding			Clad plate total thickness		Difference between calculated and actual values	
					Actual values						Calculated values			
					Yield point kg./sq.mm.	Tensile strength kg./sq.mm.	Elongation %	Yield point kg./sq.mm.	Tensile strength kg./sq.mm.	Elongation %	Yield point kg./sq.mm.	Tensile strength kg./sq.mm.	Yield point kg./sq.mm.	Tensile strength kg./sq.mm.
mm.	mm.	%	°C.											
Nickel on one side ..	9.7	1.12	11.5	20 300	22.2 14.6	38.4 43.4	29.1 22.9	22.0 15.7	39.4 44.2	28.5 21.0	20.9 15.3	40.1 44.1	- 1.3 + 0.7	+ 1.7 + 0.7
Copper on one side ..	7.7	0.46	6.0	20 300	26.1 17.8	43.7 48.9	25.2 22.0	26.9 19.0	46.0 51.0	24.0 21.7	25.8 18.2	44.6 49.0	- 0.3 + 0.4	+ 0.9 + 0.1
Stainless steel on one side .. .. on one	8.0	0.72	9.0	20 300	22.0 16.9	40.2 43.5	27.2 25.3	21.2 16.7	37.6 42.7	25.8 24.2	21.8 16.9	39.8 43.4	- 0.2 ± 0	- 0.4 - 0.1





A hemispherical cover for a 300 cu.m. cellulose digester in stainless clad steel.

that the basis metal and cladding take up mechanical stresses conjointly and bear the load applied in proportion to their thickness. The total tensile strength of the clad plate can thus be easily calculated from the tensile strengths and yield points of the basis and cladding metals. The following method is recommended for computing the physical properties of the clad plate:

Assuming the basis metal has a yield point of 30 kg./sq.mm. (42,670 lb./sq.in.) and a tensile strength of 60 kg./sq.mm. (85,340 lb./sq.in.) and the cladding a yield point of 12 kg./sq.mm. (17,070 lb./sq.in.) and a tensile strength of 40 kg./sq.mm. (56,890 lb./sq.in.) and assuming a metal cladding thickness of 10% and basis metal thickness of 90%, the aggregate yield point and tensile strength of the clad plate are calculated as follows:

Yield point:	kg./sq.mm.
Basis steel (0.9 × 30) .. ..	27
Cladding (0.1 × 12) .. ..	1.2
Clad plate .. ..	28.2

Tensile strength:	kg./sq.mm.
Basis steel (0.9 × 60) .. ..	54
Cladding (0.1 × 40) .. ..	4
Clad plate .. ..	58

If the cladding has a higher tensile strength than the basis metal, e.g. 18/8 stainless steel applied to boiler plate, then the aggregate strength will be higher than that of the basis metal. Table 1 gives the actual and calculated values, indicating good agreement between the two sets of figures.

In the design of chemical plant subjected to test code conditions and often exposed to high pressures and temperatures, the rated tensile strengths are of

vital importance. The rules set up by the German Pressure Test Code Committee in their AD-Bulletin B1 contain a method of calculating the wall thickness of cylindrical boilers exposed to excess internal pressures. These data include the following recommendation with reference to clad metal plate: 'In the case of vessels constructed of clad materials, the basis metal is generally of major importance. In the case of cladding with physical properties approaching those of the basis metal or even of higher value, the mechanical stresses will be taken up by the entire cross-sectional area.' This method of calculation has also been accepted by other European supervisory boards.

The joint between the two metal layers has been thoroughly investigated by a number of bending, tensile, torsion, annealing and quench tests and its reliability

has been proved by practical applications since 1935. The different coefficients of expansion of the two metals do not have an effect upon each other due to the intimate bonding, which is such that a composite plate is formed. Reference may be made in this connection to a recent article published by Dr. Raedeker.<sup>3</sup>

The coefficients of thermal conductivity, which are of special significance in the design of chemical plant, have also indicated that clad plate is an homogeneous material. Table 2 shows that these coefficients also vary in accordance with the proportionate thicknesses of the two metals similar to the tensile strengths.

### Welding of clad plate

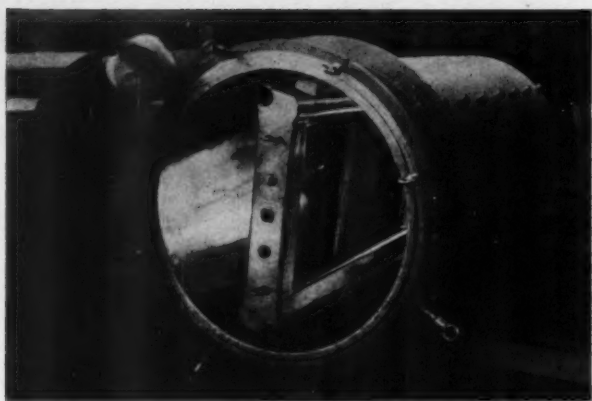
When building chemical plant, clad plate must be assembled so that the clad side provides an integral surface without any exposed areas to permit access to the basis metal. The basis metal must be so joined at the welded seams that all load stresses are taken up by the seam. After preparation according to usual practice, the workpiece is then V-grooved on the clad metal side by grinding a deep groove, after which the clad side is welded using electrodes conforming to the composition of the cladding.<sup>4</sup> When grinding, the groove must be made deep enough to permit the deposition of at least two layers of metal. Arc welding is generally employed. Direct-current welding is used on the clad side. Argon arc welding is advantageous, for instance, in the case of silver-clad metals. Modern welding practice makes it advisable to apply weld layers which are not less than 1 mm. (0.039 in.).

### Chemical plant design

In the design and construction of large vessels for the chemical and allied industries, clad metal plate has advantages over solid non-ferrous metals such as chrome-nickel steel.<sup>5</sup> Some designs are made possible, in fact, only by using clad con-

Table 2. Coefficients of Thermal Conductivity

	Cladding thickness %	Coefficient of thermal conductivity cal./cm. × sec. × °C.			Specific heat 20 to 100°
		20° C.	100° C.	300° C.	
Sheet steel .. ..	0	0.14	0.13	0.10	0.105
Nickel .. ..	10	0.14	0.13	0.10	0.105
	20	0.14	0.13	0.10	0.105
	50	0.14	0.13	0.11	0.107
	100	0.14	0.13	0.12	0.109
Copper .. ..	10	0.22	0.19	0.18	0.104
	20	0.30	0.28	0.26	0.103
	50	0.53	0.52	0.49	0.100
	100	0.92	0.90	0.88	0.095
Stainless steel .. ..	10	0.13	0.12	0.09	0.107
	20	0.12	0.11	0.09	0.109
	50	0.10	0.09	0.08	0.112
	100	0.05	0.05	0.05	0.120
Monel metal .. ..	10	0.13	0.13	0.10	0.107
	20	0.12	0.12	0.09	0.109
	50	0.10	0.10	0.08	0.116
	100	0.06	0.06	0.05	0.128



Stirrer vessel of  
nickel clad steel.

struction. For instance, a 1,200 mm. (47 in.) diameter autoclave, for a working pressure of 50 atm. (710 lb./sq.in.), at 450°C., requiring an internal copper surface, could only be made by using copper-clad heat-resisting steel with a copper cladding thickness of 4 mm. ( $\frac{1}{8}$  in.) and a steel thickness of 45 mm. ( $1\frac{3}{4}$  in.). Induction-heated chemical plant can also be constructed by using a magnetic basis metal and corrosion-resisting cladding.

#### Economic considerations

Cladding saves considerable quantities of non-ferrous metals and alloying constituents such as chromium, nickel and molybdenum. A 20 cu. m. (706 cu. ft.) capacity agitator vessel for a pressure of 15 atm. (215 p.s.i.g.), built in solid corrosion-resisting steel (18% Cr, 8% Ni, 2.5% Mo), would weigh 8,300 kg. (13,300 lb.) and require 1,500 kg. (3,310 lb.) Cr, 750 kg. (1,665 lb.) Ni and 205 kg. (452 lb.) Mo. When made of clad plate, the total weight would amount to 10,700 kg. (23,590 lb.) and would require about 120 kg. (265 lb.) Cr, 60 kg. (132 lb.) Ni, and 17 kg. (37.5 lb.) Mo. A 230 cu. m. (8,122 cu. ft.) capacity cellulose digester for an operating pressure of 8 atm. (115 p.s.i.g.) in solid plate would weigh 37,500 kg. (82,670 lb.), requiring 7,500 kg. (16,535 lb.) Cr, 3,750 kg. (8,267 lb.) Ni, and 940 kg. (2,072 lb.) Mo. If constructed in clad metal with a 3 mm. ( $\frac{1}{8}$  in.) cladding, it would weigh 44,000 kg. (97,000 lb.). The required amounts of alloying metals, however, would only be about 1,000 kg. (2,200 lb.) Cr, 500 kg. (1,100 lb.) Ni, and 135 kg. (300 lb.) Mo.

This considerable saving in valuable metals is of particular importance in present times, a fact which induced the O.E.E.C. countries to include in their rules prohibiting the use of certain non-ferrous metals, including nickel and nickel alloys, a separate clause permitting limited use of clad plate for chemical plant. The use of clad plate should also be considered from the price viewpoint. The economics of clad as opposed to solid metal plant depend, of course, on different factors such as the type of plant, the cost of the solid and clad metals, the level of wages, etc.

However, under present European conditions, plant requiring a total wall thickness greater than 8 mm. ( $\frac{5}{16}$  in.) can be economically constructed in clad steel.

#### REFERENCES

- <sup>1</sup>Clad Steels, *Materials and Methods Manual*, September 30, 1947, 98/108.
- <sup>2</sup>Raedecker and Schöne: 'Technologische Eigenschaften plattierter Bleche,' *VDI-Zeitschrift*, 19, 9, 1936, (38).
- <sup>3</sup>W. Raedecker: 'Werkstoffe und Schweissung,' Akademie-Verlag, Berlin, 1951, 819-841.
- <sup>4</sup>Heinrich Canzler: 'Bauweise mit Verbundwerkstoffen,' *Metallwirtschaft*, 1940, (37), Sept., 828-830.
- <sup>5</sup>H. Bock: 'Gestalten und Schweißen mit plattierten Werkstoffen im chem. Apparatebau,' *Ibid.*, 1942, (41/42), Oct.

### Safety Conference

(Concluded from page 543)

finalised. This saves those inevitable alterations which so often become necessary when the plant is complete and is inspected by the safety section. This routine is followed in all semi-technical and pilot plants which are erected in I.C.I.'s General Chemicals Division research department.

In discussing the ventilation of plants processing toxic products the speaker remarked on the increasing tendency to build plants in the open. However, this is not always possible and the plant, if not too large, can be installed in a well-ventilated brick cubicle with the controls outside.

Dr. Burrage concluded with some figures to prove the value of proper safety precautions. In his establishment of roughly 600 persons, comprising 350 staff and 250 tradesmen and process workers, the average number of first dressings per month per 100 members fell from 15 in 1945 to 4.3 in 1951. In almost every case half the casualties were very minor cuts and bruises and 5 to 10% were caused by grit entering eyes. During the whole of 1951 there was no lost time accident either to staff or workers.

#### Transportation and storage

The safe transportation and storage of chemicals was the subject of a paper prepared and presented on behalf of the A.B.C.M. Panel on the Marking of Con-

tainers of Hazardous Chemicals by I. E. Baggs, P. D. Moll and C. W. Richards.

The products chiefly referred to were either packaged chemicals going to another manufacturer for use in process, chemicals sold to intermediate handlers who may re-pack, re-label and sell under a different name, or chemicals which may pass through a series of intermediate handlers, but which may be intended for consumption by other industries, the professions, or the general public. The problem of ensuring safe transportation and storage has become increasingly important as the variety of chemicals manufactured has increased. The intermediate handlers also have an increasing problem, and the chemical industry as a whole has a responsibility in this field to ensure that its good reputation in these matters is maintained. The subject is attracting international attention through the International Labour Organisation. In this paper the authors, therefore, attempted to set forth some basic principles for wording for labels or other markings which they believe will assist the safe transportation and storage of the wide range of chemicals which are in day to day use. These basic principles are those on which the A.B.C.M. Panel is now working with a view to evolve a system of labelling chemicals to assist their safe transportation and storage within the confines of the U.K. Examples of various existing types of label, wall charts, etc., were given with a list of the chemicals which will form the first batch to be dealt with.

### New standards

**Milk piping and fittings** (B.S. 1864: 1952) covers milk pipes of stainless steel and tinned copper together with milk pipe fittings of stainless steel, tinned bronze and tinned gun-metal. The fittings are of the compressible ring joint type. The standard includes the following five nominal outside diameters: 1,  $1\frac{1}{2}$ , 2,  $2\frac{1}{2}$  and 3 in. For pipes it specifies details of material, dimensions and tolerances, manufacture and finish. For the fittings it specifies details of the material, dimensions and tolerances, ring joints, finish, threads and includes details or symbols to indicate joints, unions, bends, etc. (Price 5s.)

**Carboys and carboy hampers** (B.S. 678: 1952) is a revised version of B.S. 678, 'Carboys and carboy hampers,' issued in 1935. It provides for a 10-gal. balloon carboy and a 5-gal. straight-sided carboy, the latter having become popular in recent years. A great deal of development is at present taking place in the design of carboy hampers and consequently these are not specified in detail. The new standard, however, includes a very informative illustrated appendix and an appendix giving notes on safety precautions to be taken with carboys. (Price 3s. 6d.)

These standards may be obtained from the British Standards Institution, London.

# Plutonium Production Piles

## DESIGN AND CONSTRUCTION IN ENGLAND

A major task of the Atomic Energy Research Establishment is the design and construction of piles for the production of plutonium at Windscale Works, Cumberland. This production programme is described in the new official book 'Harwell.\*' The following extracts give a striking account of the chemical engineering problems involved in the production of fissile material.

BY production programme is meant that part of the research programme which bears directly on the production of fissile material. In its later stages it consists of two parts, the first being concerned with the design of the Windscale production piles, the second with the design of a chemical separation plant. The Windscale piles, like Gleep and Bepo, are graphite-moderated, air-cooled units; however, they differ from Gleep and Bepo in many important respects, and their design posed many new problems. A considerable amount of research on their design has been done at Harwell, much of it utilising Bepo as an experimental tool. The large-scale chemical separation of plutonium from uranium, on the other hand, had not been tackled in this country before. It set unique problems which are being tackled by the establishment's chemists and chemical engineers aided by Risley and by industrial contractors. In addition to research on the broad principles of the processes, there is much work to be done on the materials to be used in the various equipments.

### The Harwell piles

The first reactor built at Harwell was the Graphite Low Energy Experimental Pile, colloquially known as Gleep. Construction was started in the autumn of 1946, only a few months after the Harwell site was taken over, and the pile operated for the first time on August 15, 1947. Since then it has been in continuous use, most of the time running 24 hr. a day.

Gleep is a slow neutron reactor using graphite as a moderator and natural uranium and uranium oxide as fuel. It was designed as simply as possible, so that a reactor could be quickly available at Harwell for experimental work. To this end the design power was limited to 100 kW, so that no elaborate cooling arrangements would be necessary. A fairly full description of Gleep was published in December, 1950 (see *INTERNATIONAL CHEMICAL ENGINEERING*, January 1951, pp. 27-29).

The pile is used entirely for experimental purposes, especially for testing materials by methods to be discussed later, although for a time it was used to produce radioisotopes. For isotope production, however, and for many experimental purposes, a pile having a stronger neutron flux was necessary, and for this

reason the construction was undertaken of the second Harwell pile, generally called Bepo, for British Experimental Pile O (see *INTERNATIONAL CHEMICAL ENGINEERING*, August 1951, pp. 383-385). The design of this medium-powered pile is based on proposals made following studies at Chalk River during 1944 and 1945. The design was engineered during 1946 by Mr. (now Sir) Christopher Hinton and his staff at Risley and the pile was built under their supervision; it started up on July 3, 1948.

The main difference between Bepo and Gleep is that Bepo is designed to operate at a power of 6,000 kW. To achieve this operating power, the uranium is cooled by a stream of air drawn through the channels in which it lies. Although Bepo is rated at 60 times the power of Gleep, it is little larger, a fact which may surprise those who expect the volume of a power unit to go up roughly as its rating. The reason is this. The size of a nuclear reactor is decided primarily by the so-called critical mass, that is the mass of fissile material needed to make the reaction go; when the critical mass has been reached and the chain reaction established, the power generated depends only on the rate at which the reaction is allowed to proceed. This rate is limited by the maximum temperature at which the reactor may be operated, and hence by the rate at which the heat generated is removed.

Bepo is primarily an experimental tool, but there is also provision for making radioisotopes, which are an important by-product. Its other main use is in the study of the effect of neutrons and  $\gamma$ -rays on materials, particularly those for use in the Windscale piles and power reactors.

It was never intended that Bepo should be a prototype power reactor; nevertheless a scheme is proceeding for extracting some of the heat generated and using it to warm laboratory buildings. An earlier scheme was abandoned because the space which had been set aside for the necessary equipment was used to house a dust filter as an additional precaution against the smallest chance of a health hazard from radioactive dust in the cooling air discharged from the chimney. In the new plan, the first part of which was ready for the winter of 1951, a conventional heat exchanger in the exhaust cooling air duct supplies hot water for space-heating neighbouring laboratory buildings.

\*"Harwell," published by H.M.S.O., 1952, 6s.

Bepo has been running at high power for over three years now; as a result of the experience so gained an improved uranium cartridge has been designed which is capable of withstanding a higher temperature than the type at present in use. When cartridges of the new design are loaded into the pile, the higher permissible operating temperature will make it possible to increase the power output of the pile above the design figure of 6,000 kW.

### Work for the Windscale piles

Having obtained an idea of the characteristics and capabilities of the two experimental reactors at Harwell, we can turn now to consider the establishment's share in the design of the Windscale production piles. Obviously an important part of this contribution has been simply the experience of building a graphite-moderated pile. In addition both piles are being used to test the suitability of materials for Windscale, to check the performance of ancillary equipments and to develop operating procedures.

The need to test all kinds of materials used in a pile is dictated by two considerations, *viz.* the effect upon the pile of quite small variations in nuclear properties of materials and the considerable changes in macroscopic properties produced by irradiation.

To the nuclear engineer the most significant property of materials is the power to absorb neutrons, measured in terms of a quantity called the neutron absorption cross-section. A pile is running at constant power when the neutron population is maintained at a constant value, dependent on the power level; in these circumstances the reproduction constant  $k$  is equal to one. But more neutrons are born in fission than are needed to maintain the reaction; the excess is absorbed in three different ways: usefully in substances being irradiated, wastefully but intentionally in the control rods, and wastefully but inevitably in the structural materials or the impurities which they contain or by leakage from the surface of the pile. Clearly this wasteful loss of neutrons must be kept to a minimum so that as many as possible can be usefully employed. It may be remarked in passing that the nuclear engineer generally speaks of 'spare  $k$ ' as a measure of the fraction of useful neutrons in a pile; it is, of course, his aim to keep the amount of 'spare  $k$ ' as large as possible.



Although the neutron cross-sections of many pure materials are quite low, it requires only a very small quantity of some impurities to increase the cross-section to a value far beyond that which can be tolerated for pile use. For example, only 0.01% of boron in aluminium would nearly double its absorbing power. Indeed, some impurities are harmful in concentrations so low as to make their determination by chemical analysis a difficult matter. They can, however, readily be detected by their effect on the reactivity of a pile, and since it is usually less important to know what the impurities are than to know what the effective cross-section is, a pile can conveniently be used to check the purity of sample materials. In the Windscale programme Gleep has often been used for this kind of test. The sensitivity of a pile for this purpose is remarkable; for example, less than 1 p.p.m. of boron in graphite can easily be detected in Gleep.

Another important research contribution to the production programme has been in the development of improved uranium cartridges. It may appear strange that any great amount of research is necessary to develop so simple a structure as a rod of metal enclosed in an aluminium can, but a little consideration will show that this simplicity is more apparent than real. In the first place uranium is a metal about which comparatively little was known, so that the preparation of sufficiently pure metal, and its fabrication into rods which could be accurately machined, called for a great deal of chemical and metallurgical research. Then there was the problem of fitting the rods with a can of aluminium, and sealing its ends, in such a way that there were no holes through which radioactive fission products could escape and that there was a good contact between the can and every part of the surface of the rod, in order to ensure that the heat generated could be removed without the uranium getting too hot. This latter problem, as well as involving metallurgical research, required a method of determining how good was the thermal contact after the can had been sealed. A method of making this conductivity measurement was devised by the Engineering Division at Harwell and developed by them into a routine test procedure for use in a production plant.

Removal of heat from the bar posed many questions besides those concerning the thermal contact between slugs and cans. The design chosen for the cooling channels through the graphite is one of many compromises; on the one hand the channels must be large enough to allow a sufficient air flow without requiring a great deal of pumping power, whilst on the other hand they must not be so large as greatly to decrease the average graphite density and cause serious loss of 'spare  $k$ .' The theoretical design of such a channel is subject to many uncertainties and experi-

mental tests of the calculations are essential. These tests were made in the Engineering Division, where a section of a single channel was erected, containing special cartridges equipped with fine thermocouples for temperature measurement.

The importance of chemical research in the development of piles, as distinct from the separation of fissile material, is perhaps not as obvious as that of research in physics or metallurgy. Nevertheless a great deal of work has been done by the Chemistry Division at Harwell in various directions. In the first place the need for materials of high purity has demanded the development of special analytical techniques especially for the determination of uranium, plutonium, and certain elements which are particularly harmful in the operation of piles. Then the chemistry of certain elements which had hitherto been of comparatively little importance because of their rare occurrence has had to be examined in far more detail; this includes many of the elements in the middle of the periodic table, especially the rare earth elements which occur among the fission products. Another problem confronting the chemist has been the chemical behaviour of graphite and carbon at comparatively high temperatures and in the presence of high intensities of radiation. For example, how much of the graphite will be oxidised in the pile? If this quantity were considerable the design would be complicated by the need to allow for a decrease in the amount of graphite with time. Fortunately the chemists were able to give a reassuring answer on this point.

An interesting problem which has confronted the physicist has been to devise a method for detecting burst cartridges. It is possible that, in the conditions in which they operate inside the pile, the aluminium cans enclosing the uranium slugs will occasionally rupture. It is very important that such a failure shall be detected before it is more than a trivial crack and before any radioactive material is discharged into the cooling air. Various methods for detecting the existence of pin-holes have been studied and a machine has been developed which will ensure that a failure can be detected at this early stage. Filters in the outgoing air provide a second line of defence.

The establishment has also collaborated with Risley in the theoretical work and calculations required in the Windscale pile design. Before a pile is built it is necessary to work out not only the optimum arrangement of the uranium and graphite lattice, but also the distribution of neutron flux throughout the structure, so that the performance can be foretold as accurately as possible. Other constants of the pile have to be evaluated theoretically in connection with the design of control and safety systems, which is by no means simple. These include particularly the pile period (the rate at which its power output responds to a change in conditions), a know-

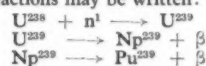
ledge of which together with the neutron flux is required before the size and speed of operation of the control rods can be decided. On the practical side the operation of the control of safety rods demands the production of elaborate apparatus, with electronic control gear, to ensure that they may be moved at the right speed and within very fine limits. The use of these controls depends, of course, upon an accurate knowledge of the neutron flux in the pile, and this is obtained by means of ionisation chambers, placed in the core, which feed electronic amplifiers and scalars. Most of the electronic equipment required for these purposes in the Windscale piles has been designed and developed in the Electronics Division at Harwell.

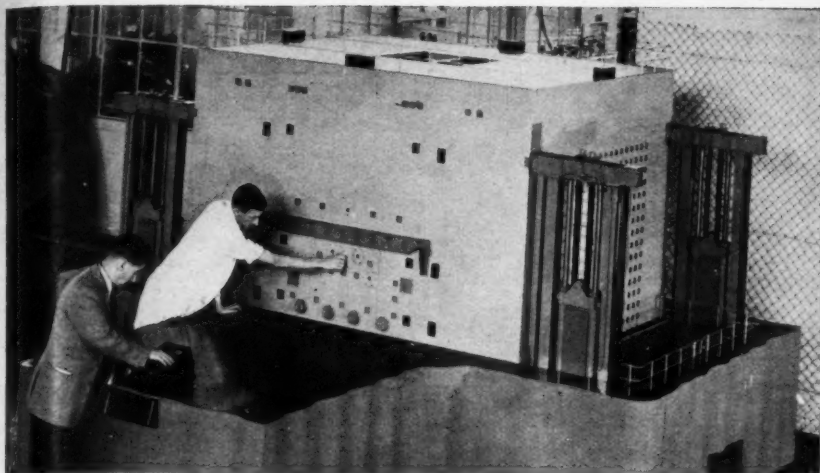
The construction of even so apparently simple a structure as the external or 'biological' shield is not merely a matter of piling up concrete to a size that looks about right; calculations are necessary to ensure that there is at all points sufficient, but not too much, shielding. The decision as to what constitutes sufficient shielding depends upon a knowledge of what are called permissible tolerance doses of radiation; this, however, is part of a wider subject which is discussed later. When the calculations have been made and the shield erected it is still necessary to ensure that practice agrees with theory and that accident does not vitiate calculation, by measuring continuously the level of radiation in the neighbourhood of the piles. This is done by means of radiation monitors connected to electronic scaling and registering units. Monitors for Windscale were designed by Harwell and are now being manufactured by industrial firms.

### The chemical separation process

We must turn now from the design of piles which produce plutonium to the extraction of the plutonium that they produce. Plutonium is a radioactive metal of fairly long life which is created atom by atom from uranium 238 by the absorption of a neutron followed by two successive beta decays.\* The plutonium is distributed throughout the uranium slugs in very low concentration and the problem is to separate it in a pure state from the fission products and from the very much larger quantities of uranium; it is also desirable to recover the uranium so that it may be used again. Because they are different elements with different chemical properties, the separation of plutonium from uranium is easier than the separation of two isotopes of the same element, such, for example, as uranium 235 and uranium 238. Nevertheless, it is still a very complicated process. The complexities arise from many factors: the very small proportion of plutonium present; the exceptional degree of purity required; but above

\*The reactions may be written:





This two-ton working model of one of Britain's largest atomic piles was shown by the Ministry of Supply at the Preston Guild Exhibition at Preston, Lancashire, last month.

all the extremely high radioactivity of all the material in the plant, and especially of the fission products. Plutonium itself is, of course, radioactive and also is extremely poisonous. Consequently every operation in the process must be done by remote control, with thick shields between the operators and the materials, and every conceivable leakage must be anticipated in the design. Such stringent requirements present the chemical engineer with difficulties probably greater than any he has had to overcome before.

Quite apart from the chemical difficulties of separating the fission products from the uranium and plutonium, there is the enormous physical problem of what to do with them when they have been separated. In a very short time the process engineers will have on their hands solutions containing hundreds of thousands of curies of activity, equivalent to hundreds of thousands of grams of radium. Such quantities of radioactivity had never been even imagined before the coming of atomic energy projects. It seems that the only way to deal with the situation is to concentrate the solutions in as small a bulk as possible and then store them somewhere until the activity has decreased to manageable proportions.

It can readily be imagined that for even laboratory-scale experiments on this process the experimenters must be particularly well protected against radiations and radioactive materials. Ordinary chemical laboratories are quite unsuited to the work and well-shielded cells elaborately ventilated are necessary. Such a laboratory takes a long time to build and some three years elapsed after Harwell was formed before the Chemistry Division had suitable, and sufficient, premises in which to carry on the programme of experiments in separation. Now the Division's 'hot' laboratory is one of the most up-to-date in the world. Until this laboratory was ready, however, work on the chemical

separation process was done mainly at Chalk River in Canada. Indeed, the development of this process exhibits one of the best examples of the close collaboration between the British and Canadian projects. All the early work was done by a mixed team of British and Canadian chemists and chemical engineers at Chalk River, and the British sections of the team have been moved over to Harwell as laboratories and equipment have become available.

In addition to the separation of plutonium there is another separation problem, less complicated but still difficult: that of extracting natural uranium from low-grade deposits in the earth's crust. So far only quite rich deposits have been worked, but as the demand for uranium expands it will be necessary to work much lower-grade deposits, and unless they can be worked cheaply and efficiently the application of nuclear energy to power production may never be economic. A mineral-dressing laboratory has therefore been set up in the Chemical Engineering Division with the main function of developing methods for the concentration of the uranium containing minerals of low-grade ores. This laboratory is mainly concerned with physical means of concentration, and works in close collaboration with two of the Department of Scientific and Industrial Research establishments. These are the Geological Survey, which advises on all matters connected with the occurrence of minerals, and the Chemical Research Laboratory, which is responsible for research on the chemical processing of them.

Another important pile material which is the subject of research is graphite. There is a need for graphite having physical, and especially nuclear, properties which are better than those of the graphite in ordinary use at present. Much experimental work on this subject is being done by industrial firms under contract to

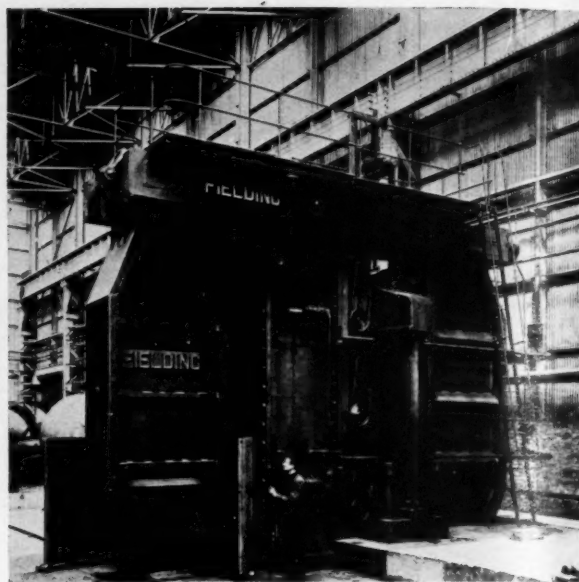
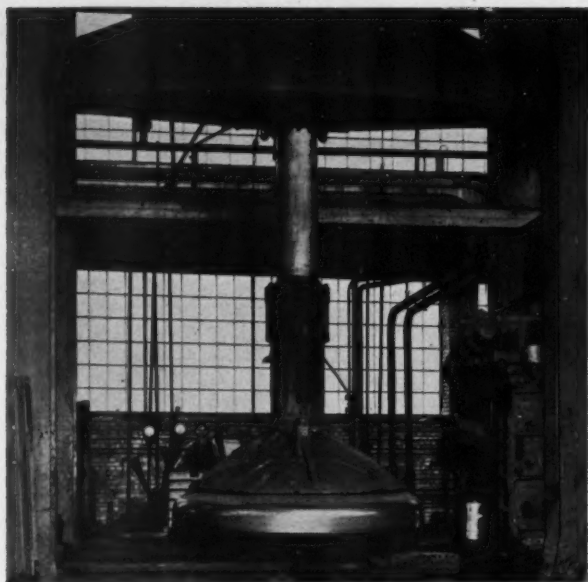
Harwell, but small-scale plant has been set up in the Chemical Engineering Division so that experimental samples can be manufactured there, and new methods and materials tested. The chemical aspects of processes leading to the production of graphite and related carbonaceous materials are under investigation in the Chemistry Division.

### Atomic power station

A diagram, which was part of the Ministry of Supply's display at the Preston Guild Industrial Exhibition, Lancashire, from August 23 to September 6, showed the research workers' conception of the atomic power station of the future. Scientists of the Atomic Energy Research Establishment at Harwell, at present working on the project, prepared this theoretical picture illustrating how electricity might be produced in an atom-powered generating station. It showed how heat from an atom pile could be used to produce steam which, in turn, would drive the dynamos to produce electric current. This method is now being investigated in research at Harwell.

It is estimated that the atomic fuel in such a plant would not have to be replaced for 15 to 30 years, and consumption of coal by British power stations is increasing so rapidly that 13 million more tons may well be required every year by 1960. In an atomic power station, the present coal and coke furnaces would be replaced by atomic piles. The resultant saving in those fuels could thus make an important contribution to the country's economy by releasing coal for industry and export. Considerable research work has already been done, and it is expected that an experimental unit will soon be built which will foreshadow the first atomic power station.

**Oil retaining bearings.** The complete range of *Reservoir* oil retaining bearings, manufactured by Morgan Crucible Co. Ltd., is described in their latest technical brochure. *Reservoir* oil retaining bearings are manufactured by powder metallurgy methods. They are tool made to precision limits, their special porous structure enabling them to hold up to 30%, by volume, of oil, providing sufficient lubrication for all but the most severe conditions of load speed and temperature. If necessary the bearings can be supplemented with further lubrication by oil soaked felt lubricators, the oil being finely filtered before reaching the face of the shaft, thus eliminating wear caused by grit. The bearings are produced in many sizes and designs, for various applications. The brochure is fully illustrated and gives full technical details. A catalogue of standard sizes of *Reservoir* bearings is complementary to the technical brochure and contains lists of the large number of standard size bushes which are normally held in stock.



(Left) The 'Rotarpress' machine at the Charlton works of G. A. Harvey and Co., Ltd., which is used among other purposes, for fabricating the ends of fractionating columns. (Right) The plate-forming and rolling machine employed for cold-rolling or bending flat plates up to 4½ in. thick.

## Fabrication of Chemical Plant

### HIGH-PRESSURE VESSELS IN FERROUS METALS

By H. B. Fergusson, M.I.N.A., M.I.Mech.E.

(G. A. Harvey & Co. [London] Ltd.)

In this article, based on a paper given at the recent Chemical Plant Symposium of the Graduates' and Students' Section of the Institution of Chemical Engineers and read in the author's absence by his son, Mr. Fergusson discusses the metallurgical, chemical and mechanical problems involved in constructing vessels capable of withstanding high pressure and vacuum, high temperature and corrosion for the chemical industry. Welding, stress relieving, corrosion and testing are some of the aspects reviewed. He concludes with notes on some first-hand experiences with unusual fabrication tasks.

EACH year sees increases in the temperatures and pressures at which chemical reactions are carried out, and the old-fashioned cast iron pans and riveted types of vessels are being replaced by welded mild steel and stainless steel containers. Many of the very large modern process vessels, particularly flash fractionating columns and towers for the oil industry, could not have been made at all but for the advent of welding. In the oil and petrochemical industries vessels have been made by welding to withstand pressures up to 1,500 p.s.i., and temperatures up to 1,050°F., and wall thicknesses of 3 in. are quite commonly used.

The manufacture of such high pressure equipment, brought about by curving thick steel plates into cylinders and making ellipsoidal heads to join the top and bottom of such vessels, and then welding all these together, presupposes that the welded joints are as strong as the plate material, and equally ductile, and that even under

fatigue conditions the fatigue endurance of the welded joints is almost as high as the plate material itself, and that the welded joints and the plate material behave isotropically, although insurance companies only allow 90% joint efficiency. To get this result a fundamental knowledge of the physics of welding, thermo-dynamics, metallurgy and chemistry is necessary, as well as a highly skilled welding. In fact, welding has now developed into a science as difficult to master as any other science. Further, the stresses which have to be considered are very complicated, especially those caused by changes in the shape of the walls of a pressure vessel when a bending moment and shear resulting from boundary conditions may change a membrane tensile stress in the cylinder shell to a sudden, very much higher tensile stress on the inner wall and a high compressive stress on the outer wall of the vessel, such as, for instance, in the torus of a thick-walled ellipsoidal closure head. Such problems

can only be solved by the use of lengthy power series and matrices, which are extremely complicated.

#### Welding operation

I propose first to deal in an elementary way with the actual welded joint. The main envelope of a pressure vessel should only have butt joints, as it is impossible to obtain as strong a fillet welded lap joint as a butt welded one. The edges of the plates must be carefully prepared to form two U's or two V's, or two V's and a nose at the centre, by machining the edges of these plates or, where the V-type joints are decided upon, flame cutting may be used. The actual shape of these U's and V's with some types of automatic welding equipment is very critical, and the best shape can only be ascertained by experience and 'cut and try' methods. When rolled into cylinders, the plates must fare accurately where the welded joint comes; this applies to the longitudinal and circum-



ferential seams of the cylinder and to the circumferential seams of the welded-on heads or ends because it is impossible to do perfect welding if these edges do not fare exactly when they are tack welded together.

We now come to the welding operation. Only covered electrodes, which are shielded by their coating, or inert gas, or powdered flux should be used. In a modern works no bare wire electrodes are used for making a welded joint. The coating of the welding rod is most important, but there is only space to mention it briefly. The coating is there, not only to shield the welding pool from atmospheric oxygen and nitrogen, but also to cover the welding pool with a protective slag, and sometimes also to add certain elements to the weld metal itself. The melting point, viscosity and surface tension of the slag covering the welding pool are all of great importance. Also it is essential that the slag can be easily chipped and brushed out after cooling, as often many runs of welding, one on top of the other, have to be made to fill up a deep V or U, and after each run the welder must remove the slag completely, because any left would be entrapped when putting down further layers of weld metal.

Most chemical vessels are electric arc welded with covered electrodes or by the submerged arc process, though often many parts and fittings may be welded by one of the various carbon arc methods, oxy-acetylene, atomic-hydrogen or argon-arc processes. Depending upon the size and type of electrodes used the operator varies the voltage across the arc; the current, his speed of welding and the length of the arc are kept as constant as possible as any lengthening of the arc will probably produce porosity in the weld and lack of weld penetration. It is a *sine qua non* that the penetration of the weld into the parent metal shall always, and at all points, be sufficient to ensure that the temperature of the parent plate has been raised to the melting point and fuses completely with the weld metal. To obtain the best results, welding is always done in the downhand position, whenever possible, although occasionally vertical and overhead welding must be resorted to in the field, in which

case only the best welders should be employed.

In the works the jobs are so positioned that downhand welding can always be used on the main seams of a vessel. This is achieved by rotating the vessel at the speed of welding when welding the inside and outside runs of a circumferential seam. With automatic welding the welding head is travelled by a monitor axially on the inside or outside of the vessel for the longitudinal seam welding. When using automatic welding equipment, capable of working at from 2,000 to 3,000 amp., the vessel is usually moved axially on a carriage under a fixed welding head for the main longitudinal outside seams.

For high-pressure vessels all the main welds of the envelope are x-rayed so that any porosity, slag inclusions or cracks in the welds can be seen on the exographs and cut out before re-welding and re-x-raying.

Ten years ago most manufacturers were compelled to cut out as much as 25% of the welding and re-weld, owing to faults in the weld disclosed by x-rays. However, by attention to detail, this trouble has been very much minimised.

### Stress relieving

Before applying a final hydraulic test on the finished vessel the whole vessel with its welded test plates is put in a furnace and heated to 620°C. to remove the very high stresses set up in the wall of the vessel by the welding processes. These stresses may reach approximately the yield point of the material and, while it is true that in theory they will disappear if the welded joint is stressed beyond its yield point (e.g. owing to excess pressure in the vessel), they are objectionable because there are always notch effects due to welded-in pipes and fittings on or in a vessel's walls. These always crack first if a vessel is stressed near its yield point. Such a crack, once started, travels with the velocity of sound, sometimes for many feet, resulting in an instantaneous brittle fracture and consequent terrific explosion. On the other hand, a stress-relieved vessel would probably first give warning by the escape

of liquid or gas from a small crack which would be unlikely to propagate until an increase in stress had been applied. Such a crack would propagate, leaving a ductile, silky fracture as against the brittle one of the un-stress-relieved vessel.

In my opinion it is either cracks in the welds or notch effects in the un-stress-relieved Liberty ships that have caused some of them to break in two. As it is impossible to stress-relieve a whole ship in a furnace it is essential that the main welds of the ship should not have any cracks in them. In particular the joining of the deck houses to the ship should be done by riveting, not fillet welding, the greatest care being taken with the hatch corners. Then, provided the steel plate used has a low transition point, that is, if fractured under test the fracture will show silky and ductile at low temperatures, there should be no more trouble with welded ships. These remarks are also applicable to pressure vessels although not in the same degree.

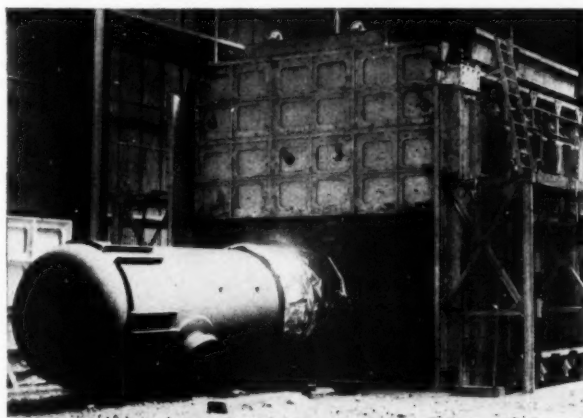
Finally, in my opinion, small clusters of porosity and small slag inclusions do not affect the strength of a welded joint. The x-ray machine is the instrument to be relied upon, within its limits, to avoid leaving a crack anywhere in a weld.

### Testing

When testing under hydrostatic pressure the proud weld metal on the inside and outside should be chipped and ground off, and the main welded seams should be given full blows with a 7-lb. hammer on each side of the weld about 2 in. from the centre line and 6 in. to 8 in. apart. The hydrostatic pressure, when the hammer test is being made, should be the working pressure. The proud metal on the weld is free to contract when cooling, and therefore not liable to crack. It thus butters over and shields the escape of water under test pressure unless the hammer test is applied with the proud metal removed.

### Martensite

Cracking troubles occur when martensite forms on the interface between the weld and plate metal. With mild steel plates this trouble is not likely except on very thick plates, say over 3½ in. thick, which, if hand welded, should be welded uphill on a slope of about 20° by what is known as the pad method of welding, using large-diameter electrodes. However, very many chemical vessels are made of alloy steels. Without a full knowledge of the art of welding, cracking of such alloy steel welds is quite common, more especially at the interface. This is due to the formation of martensite in the heat-affected zone of the plates. Martensite is an extremely hard, brittle form of carbon super-saturated ferrite, brought about by too rapid cooling of the weld and plate material. The face-centred gamma crystalline structure—which the weld and plate material have at the higher recalcrescent point—if cooled too



Stress-relieving being carried out in a 45-ft. long furnace, which has a capacity for vessels up to 14 ft. in diameter. Aluminium foil is wrapped round the shell of long vessels to prevent heat radiation when each end is being stress-relieved separately.

quickly does not have time to give the carbon, which is in solid solution with the gamma iron, an opportunity to diffuse and change into iron-carbide until a very low temperature is reached. Further, the diffusion of atomic-hydrogen through the martensite, where it forms into molecular hydrogen in the acidulated crystals of the martensite, sets up enormous pressures of thousands of atmospheres, causing cracks in the martensite. The modern use of low-hydrogen electrodes helps to overcome this trouble, but even where low-hydrogen electrodes are not used the thorough drying of electrode coatings before use helps to prevent this form of cracking.

With some types of steels the difficulty cannot be overcome except by pre-heating the work from 100°C. up to 400°C. and using large electrodes, high currents and slow speeds, as the Vickers-Hardness in the heat-affected zone is a function of its ductility and dependent on the rate of cooling of the weld. Therefore high energy in joules per in. with which the welding is done will result in a slowing down of the cooling rate.

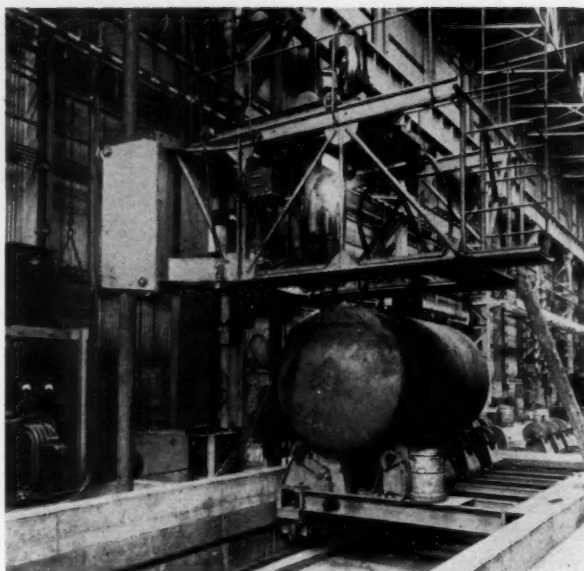
### Corrosion

Stainless steel of many different types is today used for chemical vessels. A protective coating forms on the inside of such vessels and offers a perfect resistance to corrosion if the right type of stainless steel is chosen.

For countering nitric acid, 18/8 stabilised stainless steel is adopted. This must contain a small percentage of titanium, generally with tungsten, or else columbium—the amount depending upon the carbon content of the stainless steel. Columbium has the advantage over titanium in that it does not so readily oxidise and disappear at the welding temperature, but in my opinion it is not so essential in the plate material as in the electrode used. Therefore, this type of stainless steel should be welded with columbium-bearing electrodes.

For sulphuric acid a 3% molybdenum stainless steel is satisfactory, and it should be welded with electrodes giving the same chemical deposit as the plate material. When dealing with this type of plate, titanium should not be present either in the plate or the welding rods in order to minimise the formation of sigma phase. Care must be taken in welding molybdenum stainless steel to avoid the formation of too much sigma phase. Some sigma phase is bound to form, but over 10% may result in rapid corrosion of the vessel. The sigma phase can only be eliminated by heating the whole vessel to about 1,050°C. and cooling very rapidly, if possible quenching in water, but this, of course, cannot be done with a large vessel as it is likely to all go out of shape in the furnace.

Stress-relieving is necessary for plant destined to be used with chemicals where a chloride radical is present, but it is not necessary to more than just relieve the



A 3,000-amp. submerged arc-welding machine used for welding longitudinal or circumferential seams on circular vessels. The vessel will travel up and down the pit and may also be rotated.

welding stresses by heating the vessel to 750°C. If this precaution is not taken, age cracking will occur in the form of trans-crystalline cracking in the plate material adjacent to the weld. This is quite different from the intergranular type of cracking which will always result if straight 18/8 without stabiliser is welded. In oil refinery towers 12/14 chrome-iron is often used to withstand high temperature—generally about 1,050°F., and also to withstand attack from SO<sub>2</sub> and various sulphides and sulphates found in oil refining. This chrome-iron is exceptionally difficult to weld and can only be welded hot at 300°C. at least and should be tempered as quickly as possible after welding.

Today, to avoid the expense of making the whole vessel of alloy steel, the inside of an ordinary steel vessel may be lined or clad with about  $\frac{1}{8}$  in. of corrosion-resisting metal. Chrome-iron, 12% or 13%, is often used for this purpose.

For caustic soda, nickel clad material is used. In the old days this lining was generally applied by welding on strips or by spot-welding on sheets, but now clad material is extensively used. This is made as a composite plate at the steel mills.

An outstanding corrosive-resistant lining is the American patented *Hastelloy*, which is very resistant to hydrochloric acid. This lining can be applied by using strips of *Hastelloy*, about 4 in. wide and  $\frac{1}{8}$  in. thick, and welding them round their edges to the inside of the mild steel wall of the vessel. While 25/20 electrodes may be used for the purpose the best results are obtained by using a special *Hastelloy* electrode.

Usually there is not much difficulty in welding chrome-clad material unless it has been heated in a furnace for the purpose, for instance, of shaping the heads of the vessels. However, the difficulty can be minimised if, after hot working on these

heads has been completed they are tempered in a furnace at 1,260°F. If this is not done 'crazy cracking' will be evident in the x-rayed joint. It is best with this chrome-iron cladding to use 25/20 electrodes adjacent to the clad material, and to finish off the central portion of the weld and the top runs with 18/8 electrodes, because 25/20 electrodes applied directly to mild steel are more liable to crack than 18/8 type, but this does not apply if a certain amount of chrome pick-up dilutes the 25/20, which is the case where the welding tool comes in contact with the chrome-clad material. The 18/8/3 molybdenum electrodes appear to be even better than 25/20 for this clad plate.

Without doubt the most difficult of all clad materials to weld to x-ray requirements is nickel-clad plate. I believe the I. G. Farben in Germany and the Americans tried for years to get perfect welding of nickel-clad plates without success. Recently my firm, after spending £20,000 on research, overcame this difficulty, and I understand the Lukens Co. in the U.S.A. have also reached perfection.

Nickel-clad vessels used in the manufacture of hot caustic soda must be perfectly welded. Any microscopic cracking would be immediately attacked by the caustic and, therefore, in the manufacture of such vessels the welds must show no sign of the smallest crack or pore or inclusion in x-ray pictures since otherwise the vessels would be useless.

I might add that even the welding of solid nickel plates usually results in fine hair cracks which can only be brought to light by using x-rays.

### Non-destructive testing

When examining an x-ray film it is essential to know that the focal distance and the right type of screens have been used in the taking of the film and that it has been

processed properly otherwise fine hair cracks will not show even to the trained eye of the radiologist.

My firm, apart from taking over 20,000 12 in. long films a year, uses gamma rays for investigation of faults in welds and also a supersonic detector which, in the hands of an expert will disclose, at all events on thick plate, any fault appearing on an x-ray film.

We are now using a Cobalt 60 source instead of radon. Radon has the advantage that the seed is only 1 mm. cube, thus giving a very small point source of radiation, whereas the cobalt seed is larger (it is a small cylinder 6 mm. long). We are now experimenting to see if there is really much difference in the clarity of the gamma ray pictures made by these two different sources of radiation. Radon has only 3.8 day half-life, whereas the Cobalt isotope has a half-life of 5.3 years.

### Nitric acid plant

I shall now make some random remarks on the many types of chemical vessels which manufacturers are called upon to make these days. During the war a great amount of plant was made for the synthetic manufacture of nitric acid, and a large number of nitric acid absorption towers, made from 18/8 stainless steel, had to be supplied. Some of these were 6 ft. 6 in. in diameter  $\times$  85 ft. long, and worked at pressures and temperatures requiring  $\frac{3}{8}$  in. or even  $\frac{1}{2}$  in. thick plate material. Those made to American design had welded-in, flanged bubble-cap trays, with long, rectangular types of bubble caps capable of being adjusted with stainless steel screws after installation, both axially and transversely. This method has the disadvantage that it requires a manhole for entry between each bubble-cap tray. The British design usually calls for trays which are mounted on a number of adjustable stainless steel rods which are threaded. The levelling of the tray to the machined, flanged joints of the cylinders making the vessel is brought about by stainless steel nuts on these threads, the bubble caps themselves being the more orthodox hemi-

spherical flanged type. Of course, all the welding of such vessels is x-rayed. The stainless steel cooling coils for these absorption columns are generally tested hydrostatically to 1,000 p.s.i., and the walls of the vessel are hydrostatically tested to approximately 300 p.s.i., depending, of course, on the diameter of the tower.

In the oil industry the trays are generally placed on angle iron rings welded to the inside of the vessel. Here, of course, care must be taken that the angle rings are welded on absolutely at right angles to the vessel's axis and the correct distances apart, to tolerances of  $\frac{1}{16}$  in. Inspectors will not allow any variation of these tolerances.

### High vacuum vessels

Both in the chemical and electrical industries for impregnation of coils, etc., very high vacuum vessels of considerable size are often ordered. I recollect eight vessels, 12 ft. in diameter and about 20 ft. high, with removable covers and jacketed walls, which had to withstand a test vacuum of 0.01 mm. absolute, which had to be held without a drop of more than 0.1 mm. in 24 hr. It is impossible, of course, to make a mild steel vessel in which there would be no drop whatever in vacuum. It is true that the diffusion through the steel walls can be reduced by filling the vessel with sodium-silicate and exerting as high a hydrostatic test as the vessel will withstand for 24 hr. and then heating it in the furnace to a red heat which causes the sodium silicate, which has diffused slightly into the steel, to form silicate of iron, which is a very impervious layer and prevents loss of vacuum.

A great deal could be said on the subject of jacketing chemical vessels, and there are many ways of joining the ends of the jacket cylinder to the pan of the vessel. Much depends on the working pressure and temperature inside the vessel.

### Tubular heat exchangers

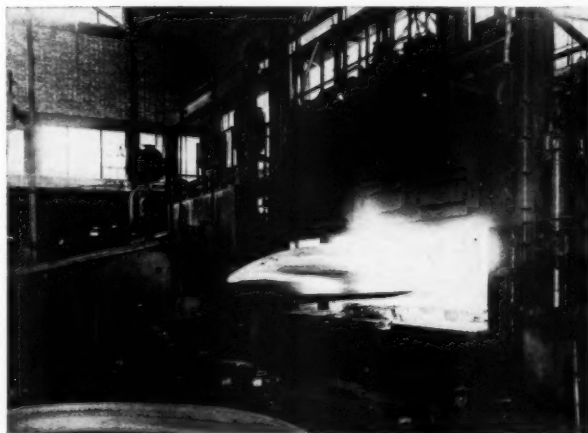
Where the tubeplates and tubes are of stainless steel it is advisable to have the

ends of the tubes upset slightly at the tube mills and for the manufacturer to put them in a lathe and just skim off the outside wall of the tube at both ends to make sure they are perfectly round and concentric. After drilling, the holes in the tubeplates should be reamed to a diameter which ensures that the tubes are a push fit into the holes and not a loose fit. The amount of expansion needed to get a tight joint should be at a minimum as excessive expansion of stainless steel tubes is liable to crack them. The same remarks apply to *Inconel* or to any material which is subject to rapid work hardening. Where possible, solid forged flanges should be avoided as they are more expensive and there is great delay in obtaining them. The difficulty can be overcome by rolling a sectional bar and resistance butt welding the two ends of the rolled bar. Such welds are usually perfect. The ring is then set up in a lathe and machined to its proper contour and is quite as good as the solid forged ring. The same remarks apply to solid forged standpipes which can be manufactured as weldings. It is true that some of the larger jointing rings, standpipes, nozzles, etc., have to be forged, and you would see at our works several hundred tons of large, solid forged rings with a sectional area of 150 sq. in., each one weighing about 4 tons. These rings are used to weld on the end of 3 in. thick cylinders 4 ft. 6 in. inside diameter, and are the bolting rings for bolting these 3 in. thick cylinders together, as well as the two tapered snouts, one at each end, used as oil gas separators by the oil wells, the test pressure being 2,400 lb./sq. in.

The high tensile bolts are all made to an exact length with a little machined pad on each end of the bolt so that when tightening up the nuts prior to testing they can be checked by using calipers with a clock gauge to strain the bolts 0.022 in. This ensures that each bolt has been strained exactly the same amount, and until this strain is taken out of the bolts by the end reaction of the vessel under test, the joints do not open out and leak before the full test pressure comes on.

### Removable covers

Where removable covers are used for closing the top of pressure or vacuum vessels the greatest care must be taken in putting them on. So often the manufacturer has tested the vessel after he has put on the covers to pressures 50% or more above the working pressure, and after he receives the vessel the client may later on take the cover off for some reason and quite often cannot get it back again so that it does not leak under working conditions. This is because he has either damaged the packing gland or, more likely, the cover has been rigidly screwed down on one side and then an attempt is made to screw it down the other side. It is necessary to tighten all the bolts lightly in a staggered manner. Begin to tighten up the bolts gradually, a little at a time, around the periphery.



ALL PHOTOGRAPHS BY COURTESY OF G. A. HARVEY & CO. (LONDON) LTD.

Final annealing of a dished end in an oil-fired furnace immediately after spinning. Coal gas burners are also used for heating such materials as pure nickel.



## High-temperature plant

Vessels sometimes have to be made to be worked at high temperatures and thus have to withstand creeps. Up to about 450°C. it is necessary to add about 3% molybdenum to take care of the creep, but where temperatures reach 550°C., or even more, such as in some modern turbines, the addition of vanadium becomes necessary, as over 450°C. the creep curve of molybdenum begins to rise steeply, whereas vanadium, although not so good as molybdenum at lower temperatures, is much better at the higher temperatures. The danger of creep causing failure is much increased by notch effects and changes in section of a pressure vessel. One only has to read the mass of data published by Dr. Bailey to realise what a very complicated matter this is. It has become much more important to meet the modern requirements for high temperatures and very close tolerances between the blades of modern steam turbines, especially as the life of such turbines must now be longer than formerly.

I recollect two mixers comprising two stainless steel jacketed pans with stirring paddles, welded to a vertical shaft, rotated by a motor mounted on a removable cover, the test pressure inside the pan being 4,000 p.s.i. The jointing ring between the cover and the top of the pan was of solid copper strip, and difficulty was experienced in keeping the joint ring tight and free from leakage at the test pressure. It was found that the flat copper ring varied a few thousandths of an inch in thickness, so the rings for both these mixers were ground on both sides to ensure an even thickness throughout. When these were replaced and the test carried out it was easy to tighten the ring bolts so that the test pressure was reached without any leakage.

In another case we had a 15 in. diameter solid nickel tube to expand into two solid nickel tubeplates. The outer tubeplate was accessible so that with a special type of tube expander there was no difficulty in expanding the tube into the tubeplate, but the inner tubeplate was not accessible. The difficulty was overcome by machining a small lead on the outer side of that end of the tube, placing the tube vertically in a container filled with frozen CO<sub>2</sub> and alcohol, turning the vessel up vertically and quickly dropping the tube into the hole of the inaccessible tubeplate and allowing the tube, in warming, to expand itself to a tight fit in the tube plate which, under test, made a perfectly tight job. Naturally, the hole in this tubeplate had to be machined somewhat smaller in diameter than the outside diameter of the nickel tube at room temperature.

## Vacuum fractionator

To give some idea of the complicated problems that arise in the design of pressure vessels, I will cite the instance of a 3,700 barrel/day vacuum fractionator column for lubricating oils, which was made in the U.S.A. The design was diameter 33 ft.,

height 81 ft., operating temperature 1,800°F., 19 bubble cap trays, 12 of which were 33 ft. diameter, total area of the trays 13,000 sq. ft. There were 5,396 risers for each 33 ft. diameter tray, and the specification called for a maximum deflection of  $\frac{1}{16}$  in. for each tray with liquid 2 in. above the weir. As the weir was 3 in. high, the depth of the liquid was 5 in., which equalled 26 lb./sq. ft. to add to the weight of the tray. The trays were at six levels, with 2 in. difference in height between each level, which meant a 10 in. fall on one side of the tray to the other side. This was done to reduce the hydraulic radiant and ensure steady flow and fixed liquid levels, thus maintaining a uniform passage of the vapours through the bubble cap slots. Cast iron trays, which were generally used for smaller diameter vessels, were out of the question, as such trays would weight 86 lb./sq. ft. each and the maximum specification deflection of  $\frac{1}{16}$  in. could not be attained. By adopting welded trays, made in sections, and manholes for each tray compartment, the trays could be made in sections, and the  $\frac{1}{8}$  in. corrosion allowance in the specification could be ignored, as any section of the tray thinned by corrosion could be examined and replaced from time to time during the operation of the column.

Built-up welded girder supports solved the  $\frac{1}{16}$  in. deflection problem. Saving in cost of the welded trays was 30% over cast iron trays, and the saving in weight on the whole column was 251 tons. The columns had to be tested with water, and when filled for hydraulic test the total weight was 2,300 tons, the weight of the tower being 700 tons and the water 1,600 tons.

The vessel was placed on a reinforced concrete ring 3 ft. thick and 23 ft. high. Inasmuch as under operating temperature the vessel expanded radially  $\frac{7}{16}$  in., radial rollers had to be provided on cast iron seats mounted on top of the concrete ring. The stiffening rings necessary when the column was being worked under vacuum were placed on the inside and not on the outside as is usual with columns not worked at such a high temperature, the reason being that it would have been difficult to keep the temperature of these rings—if placed outside—the same as the wall of the vessel, resulting in very high stresses being set up.

## Contributions

THE EDITOR welcomes practical articles and notes on chemical engineering and industrial chemical subjects with a view to publication. All contributions, which should be fully illustrated whenever possible, are carefully considered. A preliminary letter or synopsis is advisable. Address such material to THE EDITOR, CHEMICAL & PROCESS ENGINEERING, Stratford House, 9 Eden Street, London, N.W.1.

## Correspondence

### Wanted: more reviews of metallurgy

The Editor

Dear Sir: I would like to see more frequent reviews of metallurgy like that in the August issue, because they contain a considerable amount of valuable information which is only a fraction of that published in the U.S.A. and elsewhere. I feel that the articles and publications of the U.S. Atomic Energy Commission alone would provide sufficient to enable you to publish a review of this sort at least every six months, and perhaps even more frequently.

Reviews of this sort are seldom, if ever, published in the British metallurgical journals which we normally see, so that I do feel you would not be duplicating what is being done elsewhere.

There is also the point that a high proportion of the newer metals with which this review is largely concerned are produced by wet methods, against which the traditional British metallurgical industry has certain prejudices. The great majority of manufacturers of ingoted virgin and secondary metals in this country use a furnace operation, instead of a wet method to extract the metal, even though the latter may be cheaper and give far higher recovery. I quite realise that there are exceptions to this, but more often than not one finds, regrettable though it may seem, that they are closely associated with German or American concerns.

Yours truly,

P. W. WIGRAM,

O. W. Roskill, Industrial Consultants  
London, S.W.1.

We appreciate Mr. Wigram's comments. If other readers want more frequent reviews of metallurgy we would like to hear from them.—EDITOR, C. & P.E.

## Phosphatides

Their ability to act as protective colloids, as wetting and emulsifying agents, as moisture absorbents and as antioxidants makes the phosphatides a class of substances with many industrial uses, particularly in the food industry. Thus, there will be considerable interest in this new survey\* of almost every phase of phosphatide research which interprets and describes the nomenclature, isolation, structure proof, properties, synthesis, physical chemistry, enzymic relationships, analysis, sources, biochemistry, medical aspects, metabolic relationships and commercial utilisation of all the known phosphatides. All the literature up to 1949 is critically surveyed and outstanding advances made in 1950 and 1951 are included.

\*The Phosphatides, by H. Wittcoff. Reinhold and Chapman & Hall, 1951. Pp. 564 including index. 80s. net.

# New Horizons for India's Chemical Industry

The shortcomings of the Indian chemical industry and the prospects of its future expansion in many fields are described in a comprehensive and authoritative survey recently published by the Indian Chemical Manufacturers' Association.

Here is a summary of the report.\*

CHEMICAL production in India actually dates from the early 19th century. The first sulphuric acid plant was established a century ago. The industry was consolidated at the turn of the century, but its survival was threatened in the first world war. Important developments took place afterwards, and today the establishment of a large-scale chemical industry is part of wider plans for the industrialisation of India and utilisation of her natural resources. Much of the impetus for expansion came from conditions brought about by two world wars, particularly the second. Between 1946 and 1950, 60 companies were authorised to issue capital amounting to 300 million rupees for the manufacture of chemicals and pharmaceuticals.

A major landmark in the development of the industry was the passing of the Heavy Chemicals Industry Protection Act in 1931. At that time only galenicals and sulphuric acid and its derivatives were manufactured in the country.

In 1938, the Indian Chemical Manufacturers' Association was formed. It played an important part in the expansion of the following years, when the shortages of the second world war coincided with the necessity to develop India as a supply base for the Allied Armies. In 13 years, membership of the Association rose from 7 to 105.

In 1945, the Government of India acknowledged that the encouragement of industrialisation was the responsibility of the Government. The Industries Regulation Act was passed recently to empower the present Government to implement its industrial policy. This affects 25 major industries, whose future planning is to be secured by the licensing of all undertakings by the Central Government, and it controls and regulates the heavy chemicals, drugs, pharmaceutical, fertiliser and industrial alcohol industries.

The report is somewhat critical of the intervention of the Government in industry. It considers that, in certain fields, development might have been better left in private hands, that assistance ought to be given to manufacturers of raw materials and intermediates which are essential to the country's economy but for which there is not yet a profitable market, and that tariff control and import policy have, until recently, been unhelpful.

It also suggests that, although the national laboratories have been established too recently for their work to be assessed, the high cost of building them has left

little money for equipment and that they have little or no effective contact with manufacturing industries. Some progressive manufacturers have already set up their own research and control laboratories.

## Production and distribution

In spite of difficulties, mainly in connection with plant and equipment and what are considered over-generous import quotas for certain chemicals, the industry has made progress, as will be seen by the following percentage increases in production over 1946: 100% sulphuric acid, 171; superphosphate, single, 1,165; ammonium sulphate, 211; soda ash, 365; caustic soda, 375; chlorine liquid, 265; and bleaching powder, 165.

India now produces enough of the following chemicals to satisfy home requirements: alum; bichromates of soda and potash; sulphite, bisulphite, hyposulphite and sulphate of soda; sodium silicate, sodium and potassium acetate; sodium sulphide, sodium and potassium citrate; calcium and magnesium chloride and potassium bromide; liquid chlorine and bromine, chrome alum, chromic acid and chrome salts; ferrous sulphate; sulphuric, hydrochloric and nitric acid; epsom salts; heavy magnesia, naphthalene and creosote oil.

Enough of the following fine chemicals to meet home demand are also being produced: hydroquinone, x-ray developing and fixing salts, developing salts and solutions for amateur photography, calcium lactate, iron-ammonium citrate, potassium and sodium citrate, oxalic acid, metabisulphites of soda and potash, santonin, chloride of mercury and phosphoric acid and phosphates.

Liver extract, sulphonamides, codeine, morphine and hypodermic tablets are being made in increasing volume. Firms like Boots, Squibb and Ciba are having their products made in India.

Where imports and exports are concerned, many Indian pharmaceutical products sell for less than those imported, thus obviating the need for tariff protection. The value of imports of medicinal products declined from 6 million rupees in 1938-39 to 4 million rupees in 1949-50. The value of exports rose from 2.7 million rupees in 1938-39 to 8 million rupees in 1949-50.

Among the members of the Chemical Manufacturers' Association are 41 makers of pharmaceuticals, 28 of sulphuric acid and allied products, 13 of superphosphate, 13 of soaps, cosmetics and toilet preparations, 8 of textile auxiliaries, 7 of caustic soda and allied products, 6 of coal tar products, 5 each of ammonia and

bichromates, 4 of photographic chemicals and 2 each of soda ash, industrial gases and rayon. Members' factories are distributed as follows: 49 in Bombay, 25 in west Bengal (near Calcutta), 6 each in Uttar Pradesh and Bihar, 4 in Saurashtra, 3 each in Madras, Mysore, Travancore and Punjab, and 1 each in Hyderabad, Kashmir and Delhi.

## Sulphuric acid

Annual *per capita* consumption of sulphuric acid in India is 0.63 lb., compared with 125 lb. in the United States and 45 lb. in the United Kingdom.\*

The industry is an old one in India. It flourished during the first world war but suffered from competition afterwards. It revived during the second world war and is now of considerable importance owing to the food shortage and consequent need for fertilisers.

Before the second world war there were 23 units making sulphuric acid. The number rose to 36 in 1946 and then to 49. Annual rated capacity is 175,000 tons of 100% acid. There are 19 contact and 30 chamber plants. Capital invested is 25 million rupees.

Although production rose from 60,000 tons p.a. in 1946 to 102,080 tons p.a. in 1950, the industry only uses about 75% of rated capacity owing to variations in demand. The cost of production is very high owing to heavy freight charges and to the fact that most of the plants are small and uneconomic. All use imported raw materials and, at the time of writing, the industry was greatly hampered by the world sulphur shortage.

There are no known deposits of elemental sulphur in India, but gypsum occurs in Rajasthan, Madras, Kashmir and Punjab. A scheme for the manufacture of sulphuric acid from gypsum is under consideration and there are other projects for the use of this material. Large deposits of sodium sulphate at Sambhar and Didwana in Rajputana are available and about 32,000 tons p.a. could be obtained as a by-product of the salt industry. There are also deposits of pyrites in India and it is suggested that sulphur could be recovered from coal and sulphuric acid from the smelting of metals.

The report suggests that steps should be taken to make India independent of imports of sulphur, and that such economies in sulphuric acid use as the substitution of synthetic hydrochloric and nitric acid in the manufacture of superphosphate should

\*Survey of the Indian Chemical and Pharmaceutical Industry. Edited by J. P. de Sousa. Calcutta, 1952. Pp. 104 plus appendixes.

\*A more correct estimate for the U.S. is 140 lb. per head, for the U.K. 75 lb.—EDITOR, C. & P.E.



be made. New plants should be carefully planned from the point of view of size, type and location.

### Fertilisers

In view of the importance of fertiliser manufacture, the War Resources Committee of the Defence Council recommended in 1943 that the Government should undertake production of artificial fertilisers. Earlier in the year the Food Grains Policy Committee had advised that India would require between 2 and 3 million tons of artificial fertilisers p.a. and as a first step that indigenous production of nitrogenous fertilisers to the extent of 350,000 tons p.a. should be established. This led to the building of the Sindri factory (see *CHEMICAL AND PROCESS ENGINEERING*, May 1952). Production started recently. An ammonium sulphate factory was established by private enterprise in 1947 at Alwaye and, since 1939, the synthesis of ammonia and its conversion to ammonium sulphate has been carried out at Belagula, Mysore.

Lack of facilities at the main port for storage and handling of bulk materials hampers the Indian fertiliser industry. This lack of facilities will be felt more acutely when the industry expands. At present an Indian factory with an output of 10,000 tons p.a. is considered a large one. It is estimated, however, that by 1955-56 capacity in the private sector of the ammonium sulphate industry will increase to 129,000 tons p.a. against 74,000 tons p.a. at present.

Local conditions have brought about the use of nitrogenous fertilisers in a higher proportion in India than elsewhere, but there has been some change in recent years. The present report considers it desirable that this should continue.

At present 14 superphosphate plants have an annual capacity of 143,850 tons, which is expected to rise to 190,000 tons by 1955-56.

### Alkali and ancillary industries

The Indian alkali industry has been mainly developed as a result of the fall in imports during the second world war. Further shortages, developing after the outbreak of the Korean War, demonstrated the need for an indigenous industry. The establishment of this should be easy, since all raw materials are available in India. It is suggested, however, that State protection and assistance will be necessary until this basic industry is firmly established. The tax on salt, large quantities of which are needed, is criticised because it raises manufacturing costs appreciably.

At present, three soda ash and six caustic soda plants are operating with an approximate capital investment of 50 million rupees. There has been a 300% increase in the production of caustic soda and soda ash since the end of the war. Installed capacity for soda ash is 54,000 tons p.a., and for caustic soda 18,725 tons

p.a. which would normally meet 50% and 40% respectively of the internal demand for these chemicals. It is planned to raise caustic soda capacity by 14,800 tons p.a. by 1952/53. The five-year target of the National Planning Commission is 86,000 tons p.a. for soda ash and 33,000 tons p.a. for caustic soda.

### Fine chemicals and pharmaceuticals

The overall development of the Indian chemical industry has resulted in an increase in the manufacture of fine chemicals. However, exact statistics of production and consumption are not available because of inadequate classification of data and because of the difficulty of defining a fine chemical exactly. Unfavourable conditions, including the smallness of the internal market, shortage of raw materials, and a large volume of imports and Government regulations affecting alcohol and benzene have kept the production of fine chemicals below capacity. In 1946, a Fine Chemicals and Pharmaceuticals Panel reported that there were adequate resources in the form of inorganic chemicals, distillation products of coal and wood, fermentation products, petroleum products, animal products, vegetable products and synthetic chemicals for the development of a fine chemicals industry. By no means all of these resources are being fully exploited.

The foundations of the modern pharmaceutical industry were laid at the end of the 19th century and, as a result of the stimulus received during the first world war, the industry made very good progress. In 1939, India's internal requirements of drugs and medicines were valued at 50 million rupees and she was able to produce 13% of a restricted medical vocabulary. During the second world war, the establishment of an indigenous pharmaceutical industry became imperative and, by 1943, it was possible to produce 70% of a medical vocabulary about 10 times larger. Alkaloids, sera and vaccines and biological products such as liver extract were produced, and the extraction of shark liver oil developed.

India is now self-sufficient in galenicals, tablets, many proprietary preparations and parenteral injections. It is possible to produce about 75% of the alkaloids mentioned in the British Pharmacopeia from plants grown in the country.

Conditions have not been so favourable for expanding the manufacture of biological products, fermentation products, synthetic drugs and antibiotics.

Where synthetic drugs are concerned, the establishment of home production of intermediates is strongly advocated. In fact, three refineries, shortly to be set up at port towns to process imported petroleum, should do something to meet this need.

Plans for indigenous production of synthetic drugs include 50 tons p.a. of P.A.S., 720 kg. p.a. of B group vitamins and 180

kg. p.a. of vitamin D, 2,000 lb. p.a. of diaminodiphenyl sulphone and 250,000 lb. p.a. of sulphadiazine from a factory being erected. (Presumably the Atul factory at Bulsar, see *CHEMICAL AND PROCESS ENGINEERING*, August 1952, p. 443.)

A penicillin plant, financed jointly by the WHO, the United Nations Children's Fund and the Government of India will go into production in 1953. In addition a bottling plant has been set up at the Haffkine Institute, Bombay, and a private firm in Calcutta has been making penicillin on a pilot-plant scale. The latter is shortly to be expanded to commercial production.

### Coal tar distillation

Output here is not very satisfactory and has lagged behind the production of acids, alkalis, fertilisers and other heavy chemicals. The reasons are shortage of demand from consumer industries, wasteful use of tar for fuel by iron and steel plants and the diversion of a large quantity of tar for road making, as well as lack of sufficient tank wagons for transport. All coal tar produced in India is of the high-temperature carbonisation type. Yield of tar is about 4.5 gal. of tar per ton of coal, that is to say, half of that obtained in Europe and America. Indian coal tars are deficient in many important by-products such as the tar acids yielding phenol and cresols.

It should be possible to recover a much higher yield of benzole from coal by installing recovery plants in all coke oven batteries. At present, 2.7 million gal. are recovered each year, but this figure could be raised to 7.5 million gal.

### Plastics

The Indian plastics industry is mainly engaged in making finished products from imported raw materials, only phenolic moulding powders and plywood bonding resins being made locally. These are protected by tariffs, but the industry generally is not in a very satisfactory state owing to varying market conditions and the difficulty of obtaining supplies of basic chemicals. However, the number of plastics factories in India has risen from 40 in 1948 to more than 80 at the present time with a total capital of 60 million rupees and a payroll of 10,000 workers. Production in 1950-51 of plastics raw materials was between 300 and 400 tons. An analysis of imports reveals that total demand is about 5,000 tons p.a.

### Dyestuffs

The manufacture of dyes was first started in 1940 by Associated Research Laboratories and there are now six concerns making stabilised azoics and developing salts on a sufficiently large scale to meet the entire needs of the country. The colours have been found to be as good as those of imported dyes and in 95% of cases, prices are the same. At the moment, all materials are imported, but



the establishment of the new Atul plant at Bulsar should change the situation.

The present report notes heavy imports and a prejudice against dyes manufactured in India as being among the difficulties the dye industry has to face.

Indian manufacturers can now make dyes to the annual value of 6.6 million rupees. Consumption of dyes is valued at 70 million rupees. It is claimed that the banning of all imports of stabilised azoics, developing salts and Green 1B and Blue 04B from the solubilised vat group would give the industry a good chance of expanding sufficiently to meet local needs.

#### Other chemicals

Bichromates production flourished during the second world war, but was adversely affected later by rising costs, the effect on the tanning industry of Partition and strained relations between India and Pakistan, heavy imports and changes in Army requirements. However, the industry is now receiving protection and assistance from the Government and its future is considered to be well assured.

Magnesium chloride is a by-product of the manufacture of salt. Ample raw material is available in the form of pit-brine at Kharaghoda in the Gulf of Cutch, and Indian magnesium chloride is widely exported. The following chemicals are now being made either direct from the 'bitterns' left after salt manufacture, or after further chemical reaction: magnesium chloride, magnesium sulphate, magnesium carbonate, calcium chloride, bromine and bromides, mixed potash salts and basic light magnesia.

About 80% of the 2,500 tons of potassium chlorate required annually in India is manufactured at the Wimco match factory, Ambernath, Bombay, from imported potassium chloride. Indigenous potassium chloride is not sufficiently pure for this purpose. Production of potassium chlorate has doubled since 1945 when between 900 and 1,100 tons p.a. were made.

Crude saltpetre is available in Punjab and Uttar Pradesh. Production used to be about 15,000 tons p.a., but dwindled after the Partition of India, and is now very expensive. Some producers re-refine saltpetre for sale to manufacturers of bichromates. Chlorine and bromine are produced in India, the former to the extent of 4,000 to 5,000 tons p.a. and the latter to the extent of 180,000 lb. p.a. Hydrogen is used mainly for the hardening of vegetable oils. The demand for nitrogen is small and it is only produced as a by-product of oxygen.

Manufacture of nitrous oxide was started in January 1944, the country's entire requirements being met by one plant in Calcutta. Demand is rising after a fall at the end of the war, but raw material difficulties are being felt.

Oxygen is often produced as a by-product of the electrolysis of water and

there are both major production units and a number of compressing stations. This is because of the cost of transporting heavy steel cylinders for the long distances. Production of oxygen in India began in 1914 and was greatly expanded in 1935. There are now 20 plants with an output many times greater than in 1935. Dissolved acetylene factories were first started in 1926 or 1927 and output has risen more markedly than that of oxygen. Prices of oxygen and dissolved acetylene are now lower than in 1935.

A new method of supplying bulk liquid oxygen to consumers' works, thus obviating the need for cylinders, is now being developed.

Production of photographic chemicals, after rising sharply during the war, was adversely affected by imports. These were curtailed in 1949 in order to save foreign exchange and the situation is improving. However, there is an unfortunate prejudice against local chemicals on the part of the Indian film industry, which is an even greater disadvantage than a high volume of imports.

While hard and soft soaps have been made in India for a long time, other textile auxiliaries were not produced before the beginning of the present century. It is estimated that about 12,000 tons p.a. of auxiliaries including sizing, softeners and size preservatives are now consumed by the textile industry and that 60 to 65% of its requirements are supplied by local manufacturers. It is suggested that alternatives could be found to the materials now imported and that new auxiliaries using indigenous raw materials should be developed.

#### Future needs, plans and trends

Among the most important needs of the Indian chemical industry is an overhaul of railway rates, which are heavy and continually being raised without consideration of the ability of the traffic to bear the charges. Freight on caustic soda for a distance of 700 to 1,500 miles amounts to between 10 and 20% of the price of the chemical. There are no concessions on coal traffic for the chemical industry, although rebates have been granted to the textile, cement and paper industries, and there are no wagon load rates for sulphuric acid, which is transported in large quantities to meet the needs of almost every major industry.

Since the first courses in chemical engineering were started in India in 1921, the number of students graduating every year has risen to about 200. At the moment there are not enough vacancies and consolidation of existing facilities for chemical engineering education rather than their expansion is advocated.

Plans for the Indian chemical industry in the near future, in addition to those already mentioned, include the manufacture of 500 tons p.a. of benzene hexachloride and the establishment of a State-

owned DDT plant by 1954 at Kalyan, Bombay, with a rated capacity of 750 tons of 100% powder p.a.

The principal trend is towards the development of the fertiliser industry, because of the pressing need to increase food supplies.

The report considers that production of coal tar chemicals could be developed, provided that an intermediates industry could be established and protection from foreign competition assured, that the annual production of 2 million gal. of benzene and 500,000 gal. of toluene might form the nucleus of such an intermediates industry; that a fermentation industry could be developed with the ample supplies of molasses available in India; that the use of alcohol as a basic raw material is bound to increase as well as the use of inorganic chemicals; and that drug manufacturers should produce a bigger variety of drugs. In this context, Indian herbs known to have therapeutic value should be investigated scientifically, as should the many Indian fungi which might provide new antibiotics.

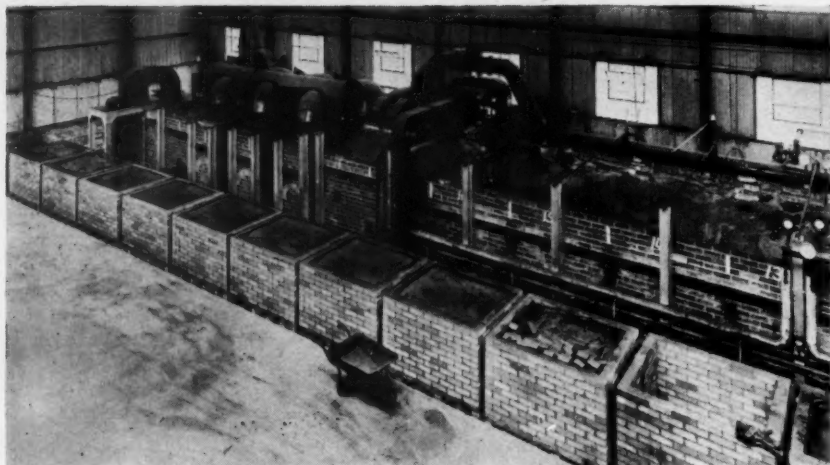
### Recent publications

**Rotary vacuum filters.** By means of film inserts showing sectional views and photographs, Davey, Paxman & Co. Ltd. describe their rotary vacuum filters for separating solids from liquids in their new publication, No. 1269. These filters are used largely for filtering coal slurries, paper pulp, chemical slurries, sewage and effluents, and food and allied products. They are built in cast iron, mild steel or other materials, and can be lined according to the slurry to be filtered.

**Scientific instruments.** In their latest catalogue, No. G, W. G. Pye & Co. Ltd. describe their wide range of scientific equipment, including a pH meter which provides direct-reading pH ranges of 0-8, 6-14, and a milli-volt range of 0-800 and 600-1400 m.v. respectively. Other equipment described in this catalogue are resistance bridges and boxes, potentiometers, Scalamp galvanometers, with built-in optical system and scale, and a variety of magnetic instruments.

**Hammer granulators.** When it is required to reduce hard materials to a cubical product with a minimum of fines and oversize a swing hammer granulator is a suitable unit. In the company's latest publication (No. 1450 B), British Jeffrey-Diamond Ltd. describe their swing hammer granulators. Built in four sizes, 15 × 8 in., 20 × 12 in., 24 × 20 in. and 36 × 24 in., these granulators will reduce brick, burnt lime, chemicals, fireclay, gravel, gypsum and similar materials from large pieces to the required sizes in one operation. The granulators can be arranged for use with flat belt drive, 'V' ropes, fast and loose pulleys, or flexible couplings for direct drive.

## New Plant Increases Output of Carbon Refractories



The new tunnel kiln showing cars with built-on containers in the foreground.

THE lighting-up recently of the new tunnel kiln at the Loxley works of Carbox Ltd. represented the culminating point of an expansion scheme that has been taking place over the last two years. This new class of refractory has been developed and successfully marketed during the past few years. The development began when two companies associated in order to study and manufacture carbon refractories, at the request of the iron-making industry. These two companies were Thomas Marshall & Co. (Loxley) Ltd., of Loxley, Sheffield, and the Morgan Crucible Co. Ltd., of London, and the company so formed was Carbox Ltd., of Storrs Bridge, Sheffield. Marshall's brought with them over 100 years' experience in the manufacture of refractories and Morgan Crucible a similar wealth of knowledge in the handling and manufacture of carbon. Together they investigated, developed and produced Carbox refractories.

Within a very short time, so successful was this product, that it became apparent that the demand, both home and overseas, for this type of refractory was far outstripping the production capacity of the original pilot plant. With improved manufacturing methods and technique it was possible to increase output. Thus, within three years of commencing full-scale manufacture, Carbox had more than doubled their output and have continued to increase their production every year. Even these efforts did not solve the ever-growing problem of supply and demand, and it was obvious that new plant would have to be erected.

The board of Carbox put in hand a programme of expansion involving the erection of new buildings and plant ultimately to quadruple the 1950 output. The starting-up of the tunnel kiln, already mentioned, represented the end of this

second phase of Carbox history—a phase which it is anticipated will meet all the demands of the iron and chemical industries for many years to come.

The overall dimensions of the new tunnel kiln are 133 ft. long, 18 ft. wide and 12 ft. high. It has a capacity of 23 cars which are 5 ft. 6 in. long and 5 ft. 3 in. wide. The cars are fitted with built-on containers which each hold approximately 3,500 lb. of Carbox carbon products and packing. The car schedule is one car per 2 hr., giving a total output of 100 to 140 tons per week, according to the type of material produced.

The kiln is of a special design and is capable of dealing with the volatiles given off from the green ware without resorting to any extra kilning space. This design enables a short operating cycle to be employed and appreciably increases production. Automatic temperature control ensures suitable conditions throughout, maintained to limits of  $\pm 10^{\circ}\text{C}$ . Fourteen temperature recording points throughout the length of the kiln are connected to potentiometric recorders and controllers of the latest design.

The firing system is unique in that it has been designed primarily for oil-firing, using heavy fuel oil, but provision has also been made within the kiln structure to use part, or all, of the volatiles given off by the charge as an additional heating medium. The controls mentioned above operate the oil fuel valves to give the correct firing temperature. Another interesting feature of the kiln is that there is no large brick-built stack. The control of the exhaust is effected by a venturi system which obviates the necessity for a large brick structure.

The kiln will be used for the production of all forms of carbon refractories, and will play an important part in increasing the already appreciable export business of this company.

## Fuel Gases from Oil

THE rapidly spreading network of pipelines carrying natural gas into many sections of the U.S.A. promises new prosperity for another branch of the gas industry—the manufacture of fuel gas from petroleum, according to W. A. Kohlhoff, chief engineer of the Portland Gas and Coke Co., U.S.A., writing in *Industrial and Engineering Chemistry*. High heat value oil gas, manufactured locally, can be used to supplement supplies of natural gas by helping to meet peak seasonal demands for natural gas and by providing standby capacity for emergency use.

In many areas where natural gas is in use, manufactured gas generating equipment has been converted to produce oil gas with a high heating value. This gas is interchangeable to a large degree with natural gas. High heat value oil gas, a recent development of modern fuel gas research, has almost twice the 'heating power' of older types of manufactured gas and about the same as natural gas.

Older type manufactured gas has a heat value usually ranging from 500 to 600 B.Th.U./cu. ft. of gas and natural gas has a value of about 1,000 B.Th.U./cu. ft.

The manufacture of oil gas is particularly suited to effective auxiliary operations. Relatively inexpensive petroleum raw materials for oil gas manufacture are in adequate supply. Initial capital investments and replacement costs are generally lower than those required for other manufactured gas processes. In addition, other processes usually require longer periods of continuous operation to obtain profitable gas production.

During the past few years the manufacture of fuel gases from oils has taken on a new significance for U.S. gas manufacturing companies, according to Kohlhoff. Oil gas plants which a few years ago were limited chiefly to the Pacific Coast are now being developed in various other sections of the country. Plants formerly using other fuels and processes are being converted to the oil gas process. Valuable chemicals, motor fuels and road tars are by-products of oil gas manufacture and profitable yields of these materials could justify the continuous operation of high heat value oil gas plants even after the introduction of natural gas.

The first development in the production of fuel gases from oils is credited to John Taylor of England, who received a patent in 1815 for his process of making illuminating gas from oil sources. In the U.S., with its abundance of coal and coke for making gas, there was no substantial production of oil gas until the beginning of the 20th century. Oil by that time was cheaper than coal in the Far West, and with the development of an improved

(Concluded on page 560)

# Fluorspar and Fluorine

By J. L. Boyle, Ph.D.

Fluorspar is a mineral which has long been of economic importance, the demand for it amounting to some half a million tons p.a. Production is likely to rise because fluorspar is the biggest source of fluorine, the industrial importance of which is steadily increasing as new uses for this most reactive halogen are found. In this article the author briefly explains the industrial uses of fluorspar as such and its favourable prospects in the light of advances in fluorine chemistry.

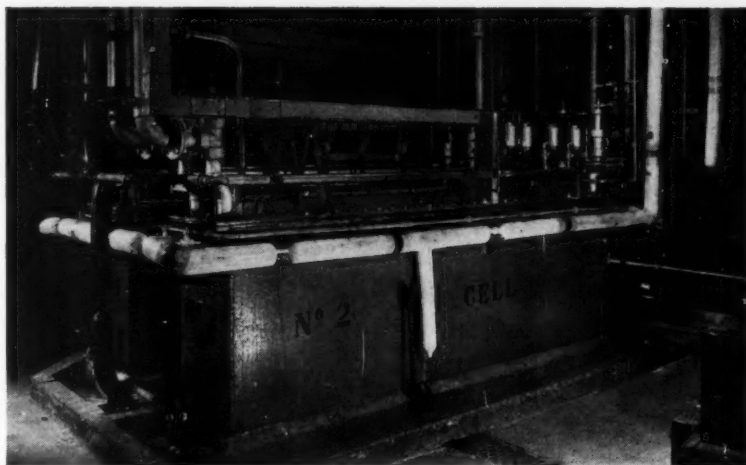
FLUORSPAR is fairly well distributed throughout the world. The biggest producer is the U.S.A. and, in pre-war years, Germany ranked next. The U.K. is third with about 50,000 tons p.a., which is found in association with the lead and zinc veins of Derbyshire and Durham, particularly the former. For this reason, it is often called Derbyshire spar in Britain.

Chemically, the mineral consists of calcium fluoride with small quantities of silica, sulphur, barytes and sulphides of lead and zinc present as impurities. Normally it is sold containing at least 85% of calcium fluoride, but for chemical purposes a purer product is required. For metallurgical uses it is common to assess its value in 'effective units,' which are arrived at by reducing the calcium fluoride percentage by  $2\frac{1}{2}$  times the silica percentage. This is done because at the high temperature of a steel furnace where fluorspar is used silica reacts with that proportion of calcium fluoride, rendering it useless.

## Metal industry

Fluorspar is mostly used for steel melting where it is added to the furnace just before tapping the charge, in order to make the slag more fluid. The quantity added varies a good deal from works to works, but is of the order of 5 to 8 lb./ton of steel made. In basic open-hearth furnaces the slag has a high proportion of phosphorus and for this reason it is processed and sold as fertiliser. When this is done, the amount of fluorspar which may be added to the furnace charge is limited, because it reduces the solubility of the phosphates in citric acid. This test of solubility in citric acid is the criterion of a basic slag's value as a fertiliser, in the U.K. at any rate.

There are several other metallurgical uses, one being the production of aluminium. Because of its high solvent power for alumina and electrochemical stability in the molten condition, cryolite is used as the electrolyte in the electrolytic reduction stage of the manufacture of aluminium. Since cryolite is a rare mineral, fluorspar, together with alumina and soda ash, is treated so as to give a synthetic cryolite. This synthetic form is widely used, and a purer grade of fluorspar is needed than for the steel furnace. This is the source of the fluorine which is liable to contaminate the land and other surroundings of an aluminium works unless the fumes are cleaned before emission.



Electrolytic cells for the commercial manufacture of fluorine.

(THIS AND THE PHOTOGRAPH ON P. 560 BY COURTESY OF IMPERIAL SMELTING CORP. LTD.)

## Ceramics industry

Fluorspar is used to make glass and enamels opaque. This application to ceramics is at present the second largest outlet for the mineral and for certain special glasses the proportion of it used may be as high as 40% on the weight of silica glass. The presence of metallic impurities such as iron oxide, the sulphides of lead and zinc and barytes are objectionable and a suitable fluorspar for this purpose would be one containing 96%  $\text{CaF}_2$ , 2%  $\text{SiO}_2$  and 1%  $\text{CaCO}_3$ . The demand for the mineral by the ceramics industry shows no sign of diminishing; in fact it is already back to the peak figure of 1944 and this is likely to be maintained since there are no competitive substitutes at present.

## Chemical industry

The chemical industry demands the highest quality fluorspar and pays the highest price for it. For this reason and since the consumption for the manufacture of chemicals has been steadily increasing, it has become worthwhile to separate the mineral into grades and recover as much as possible of the high quality material. This classification is usually done by flotation methods.

For the chemical industry, fluorspar is the only source of fluorine. The element is present in other rocks and clays, but either they are inaccessible and rare, as in the case of cryolite, or fluorine occurs only in traces and is difficult to recover, as in phosphate rock.

## Refrigerants

The demand for a stable, harmless and non-inflammable fluid for household refrigerating machines led to the development in the U.S.A. of the *Freons*—the trade name given to a group of hydrocarbons in which the hydrogen has been replaced partly by fluorine. The best known of them is *Freon 12*, which is dichlorodifluoromethane. Imperial Chemical Industries now manufacture these fluids in the U.K. using the trade name *Arcton*. These compounds are very successful as refrigerants and gave rise to the need for making anhydrous hydrofluoric acid on an industrial scale, since this acid is the fluorinating agent in their manufacture.

## Petroleum

Another quarter from which developed a demand for anhydrous hydrofluoric acid (AHF) in the 1930s was the petroleum industry. The performance of aviation fuel is greatly improved by the addition of iso-paraffins. Since they occur only to a small extent in natural petroleum, they have to be synthesised if large quantities are wanted. One successful method of synthesis uses AHF as a catalyst in building up iso-paraffins of the desired complexity from simpler compounds. The importance of this process may be gauged from the fact that at the peak period during the war, these iso-paraffins were being produced at a rate of 5,500,000 tons p.a. This caused an increase in the production of AHF from 6,600 tons in 1939 to 38,500



tons in 1945, with a corresponding increase in the demand for high quality fluorspar.

### Uranium

During the war the interest in fluorine and its derivatives was intensified by a discovery in quite a different field. In the researches into the subject of nuclear fission and the practical possibility of an atomic bomb, a point was reached when a suitable method of purifying uranium had to be worked out. It was found that the only gaseous compound of uranium was its hexafluoride and a process based on the volatility of this compound offered a means of obtaining the metal in the required degree of purity. Unfortunately, uranium hexafluoride is unstable and easily breaks down, giving rise to fluorine, which is an extremely reactive and corrosive gas. For this reason all constructional materials, linings, lubricants and refrigerants must be resistant to the action of fluorine.

### Fluorine chemicals

This quality is present in a class of compounds which are themselves fluorine derivatives, namely the fluorocarbons. Therefore, a great deal of work was done on these compounds to find some which would be satisfactory for the purposes of the atomic energy project. From this work a new field of applied chemistry has developed, for it has led to the large-scale manufacture of elementary fluorine from fluorspar, and on from that to several finished products which have already established themselves in industry.

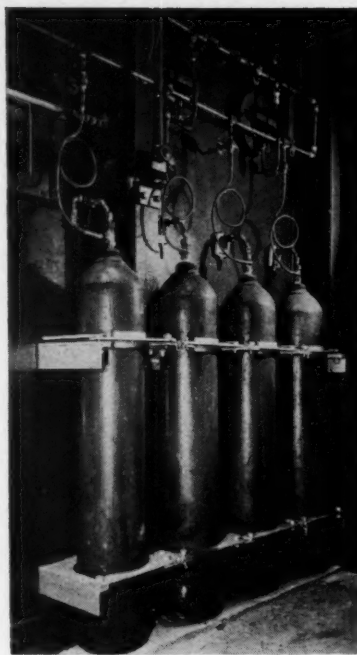
One of these, sulphur hexafluoride, is a gas which, because of its high dielectric constant, is an excellent insulating medium for high-voltage equipment. It is made by the interaction of sulphur and fluorine.

The fluorocarbons are hydrocarbons in which hydrogen has been replaced completely or partly by fluorine. The Freons, mentioned above, are one section of this group, but the availability of fluorine on an industrial scale has greatly extended it and made possible the attainment of complete fluorination of a molecule. The first fluorocarbon is carbon tetrafluoride, the analogue of methane, and I.C.I. have announced their intention of making this unreactive gas one of their range of fluorine derivatives.

These fluorocarbons range from gases to waxes and a good deal of work has been done to apply the high-boiling members to specialised and difficult problems of lubrication. They are also expected to find applications in chemical synthesis.

### Tetrafluoroethylene

Just as ethylene can be polymerised to give the plastic, polythene, so tetrafluoroethylene, i.e. ethylene in which all the hydrogen has been replaced by fluorine, gives an analogous polymer which is known commercially as *Teflon*. This plastic is acquiring an industrial reputation because of its outstanding resistance to



Station for filling fluorine into cylinders, a recent development in the handling of this gas.

corrosion and its good electrical properties. Other polymers from fluorocarbons are being produced on a large scale and it is possible that a range of such products, each specially designed to meet a particular need, will soon be available to the synthetic resins industry. Fluorine oils and greases which are resistant to chemical attack are also being made.

Finally, fluorine is being tried as a raw material for fungicides, insecticides, germicides and pharmaceuticals. Because of these and other possible developments in fluorine chemistry the outlook for fluorspar is extremely promising.

### Camels and catalysts

There is an old, old story of the Arab who bequeathed to his three sons, respectively, one-half, one-third, and one-ninth of his fortune. Upon his death, his property consisted of 17 camels, which number obviously is not divisible by two, three, or nine. A sheik who was called in to settle the dispute agreed to add his personal camel to the lot, making a total of 18, whereupon, by the terms of the will, one-half, or nine camels, was awarded to the first son; one-third, or six camels, to the second son; and one-ninth, or two camels, to the third son. The camels thus distributed were nine plus six plus two, or 17. Lo and behold, one camel remained as the property of the sheik. Great is the power of Allah! The 18th camel made the entire distribution possible yet played no final rôle in the reaction. That is the definition of a catalyst.—P. D. FOOTE, *Scientific Monthly*, May 1952.

## Syntheses of organic chemicals

The new edition\* of this 'annual publication of satisfactory methods for the preparation of organic chemicals' lists 42 compounds in alphabetical order and has a collective index covering this and the previous volume. Among the interesting compounds for which methods of preparation are given are benzofurazan oxide, coumalic acid, ethyl pyruvate, laurone, syringic aldehyde and triethyl phosphite.

Contributions are invited, as in former years, from chemists who wish to publish procedures for the preparation of compounds of general interest or which illustrate useful synthetic methods.

\**Organic Syntheses*. R. S. Schreiber, Editor-in-Chief. Vol. 31. Chapman & Hall, 1951. Pp. 122, including index, 22s.

### Fuel Gases from Oil

(Concluded from page 558)

production process oil gas became an important fuel in that region.

Oil gas produced in the U.S. from 1920 to 1929 provided 7 to 8% of the total manufactured gas. These figures indicate that, from a national viewpoint, oil gas was not of major importance during this period. However, it was of great local importance, particularly in the major cities of the Pacific Coast states where for many years, because of lack of coal supplies, oil gas was the only gaseous fuel produced on an industrial scale for public distribution.

In the late 1920's, through improvements in pipe manufacture and transmission facilities and the discovery of large reserves of natural gas, natural gas transportation became possible to ever-increasing distances from the Southwest fields. Currently, the Pacific Northwest is the only region in the U.S. which does not have natural gas scheduled. However, the large gas reserves in Alberta, Canada, would seem to ensure the eventual introduction of natural gas into this region.

The introduction of natural gas has created problems for gas manufacturers in all parts of the country. Of chief importance has been development of methods for meeting peak loads and providing standby capacity for emergency use or during times of curtailment of supply. Some producers of coal gas, carburetted water gas, and low B.Th.U. oil gas deemed it necessary to devise methods of using their existing plants for the manufacture of a fuel having a higher heating value—about 1,000 B.Th.U.—to supplement natural gas. Much interest has been shown in the extensive research sponsored by the American Gas Association toward the production of a high B.Th.U. oil gas which can, to a large degree, be interchangeable with natural gas.

# Plant and Equipment

## Ultrasonic thickness gauge

Chemical plant tends to be operated at higher and higher pressures and the need for reliability is increasingly greater. On inaccessible plant, however, it is often extremely difficult to obtain an accurate estimate of wall thickness, and thus of corrosion, by normal mechanical methods. These problems can now be overcome by means of an ultrasonic thickness gauge recently introduced by Dawe Instruments Ltd. This gauge does not damage the wall in any way and yet it is said to enable an accurate measurement of thickness to be obtained where only one surface is accessible to the operator. This means the wall thickness of chemical and other plant can be measured while it is actually in operation. In any installation where continuous working is normal, such as for petroleum refining and many other processes, this is very important, since any unnecessary shut-down involves considerable losses.

The ultrasonic thickness gauge is simple to use and readily portable, since it measures only  $12 \times 14 \times 8$  in. and weighs 23 lb. It is self-contained and requires no external power supply and can thus equally well be taken into the holds of tankers or inside pressure vessels and boilers or into the middle of a desert to check the thickness of an oil pipeline.

The accompanying illustration shows the gauge being used to measure wall thickness on the end of a fabricated receiving vessel. The metal thickness being measured in the illustration is about  $\frac{1}{2}$  in., but the Dawe ultrasonic thickness gauge has an effective range of from about  $\frac{1}{16}$  to 12 in. in steel and proportionately for other materials. The photograph was taken at the works of G. A. Harvey & Co. (London) Ltd., manufacturers of oil refinery and chemical plant. The firm carried out a series of tests on a set of test blocks with thicknesses of known values. The thicknesses gauged varied from  $\frac{1}{16}$  to  $3\frac{1}{2}$  in. and the greatest deviation anywhere in the range from the figures given by a micrometer was 1%. An accuracy of 3% is, however, guaranteed by the manufacturers of this instrument.

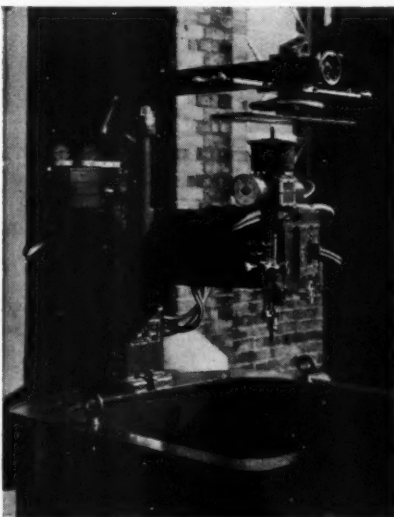
Briefly, the gauge works on the principle that a signal injected into the one accessible surface will be reflected by the far, and inaccessible, wall. When the path length of the signal, i.e. twice the wall thickness, forms a certain relationship with the wavelength of the injected signal, there is a marked increase in the signal reflected back to the gauge. Knowing the wavelength, the wall thickness can then be found. The gauge can be applied directly to quite rough surfaces, though, for very corroded conditions, it is advisable to prepare a small area with a hand grinder.



Checking the thickness of one end of a receiving vessel using an ultrasonic thickness gauge. All the necessary equipment can be seen in the illustration. The thickness of the plate can be read directly off the instrument dial.

## Improved oxy-acetylene cutter

An improved version of their 36 in. universal oxy-acetylene cutting machine is being produced by The British Oxygen Co. Ltd. Although the major structural arrangement remains unchanged, examination reveals many modifications. The general appearance of the machine is much the same as the original, since basic movement and capacity, e.g. cutting radius 36 in., maximum cutting thickness mild steel, 6 in., remain unaltered. In detail, however, the new machine has modifications covering the cutter and its controls,



Universal oxy-acetylene cutting machine.

the oxygen control panel, the speed control for the template follower, and a new drive to this last. In addition, there are other small refinements.

An innovation that will be welcomed by machine operators, is the introduction of the M.C.6 cutter which uses the B.O.C. one-piece nozzle. The adoption of the one-piece nozzle on this machine with the advantage of trouble-free operation and the ease with which nozzles can be changed is a most important feature. A further advance is that a powder cutting attachment can be attached for profile cutting. This will be available shortly and should prove of great interest to industry for it will greatly extend the scope of the machine. The cutter is finished in chrome and all corners have been rounded so as to make cleaning a much simpler task. The gas controls on the cutter now have colour identification and are much larger.

The speed control has been changed and a rotary rheostat replaces the old type sliding model. The 'on-off' and the 'forward and reverse' switches have also been altered, and together with the rheostat they have been mounted on a neat panel on the outer arm. The gate arms too have been modified, the cast girder-work being replaced by a neat panelling which tends to lighten the arm and at the same time results in a cleaner appearance.

Another innovation is the oxygen control panel mounted on the left-hand side of the pillar and protected from damage by a chromed steel strip. The panel consists of the latest type O.R. 13 regulator which has been split up to enable grouping of the gauges at the top of the panel. A cutting chart is also included. The acetylene supply is still controlled by an A.R.9 regulator fitted to either a cylinder or a manifold. Below the control panel is a master 'knock-off' valve which governs both the oxygen and the acetylene supply to the cutter, enabling all gases to be cut off with one movement.

The re-designed transmission to the tracer head incorporates an oil bath in which the oil level is visible through a glass panel. The lead screw cross slide template adjuster, has been retained. A further refinement is the provision of a hinged bracket on the pillar which can be fitted over the magnet roller and so prevents movement of the arm when the machine is not in use, or when the work is being set up.

## Electric resistance heating jacket

An electric resistance heating jacket is being marketed by the Stablag Co. Ltd. It provides direct heating of liquids at a constant heat wavelength within the infra-red range and is particularly suitable for viscous liquids, since it provides uniform heating over a large surface area. The jacketing is constructed from Fibreglass or quartz cloth in which is secured a closely pitched resistance wire. All the heating

wires run vertically and the difference in electrical potential between the adjacent wires is negligible. Each jacket is designed with multiple circuits, each circuit being equal in area, until the vessel or pipeline is completely encircled and the whole surface in contact with the jacket is evenly heated. The form of construction is claimed to give exceptional strength and the design is such that, even if a vessel or pipeline is allowed to run dry, there will be no deterioration of the fabric and no damage to the vessel.

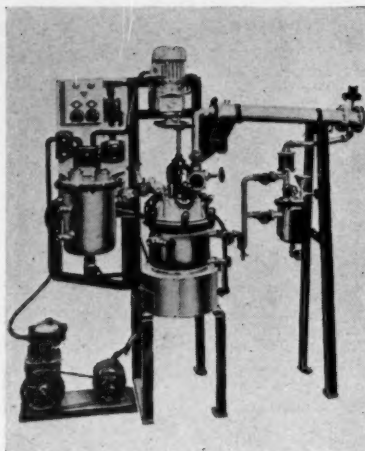
The illustration shows a small pilot plant incorporating a *Stabilag* electric resistance heating jacket, which is being used for research in a South African paint works. Advantages are claimed to be the low cost of installation and straightforward connection to the electricity supply. The plant is portable and it can be temperature controlled accurately within a few degrees by merely turning a knob. The jacket is designed for rapid heating and cooling without elaborate instrumentation. There is a saving in metal, as no pressure exists in the jacket and a lighter gauge material can be used. There are no valves or pipelines to fix as with steam jackets.

The *Stabilag* system of heating can be used on fume bends and condenser columns, for preventing the building up of resin. On drain-off valves, which are the cause of frequent trouble, it solves the problem of resin hardening off in the cold pipelines connecting to the valves. Its use on pipelines is helpful where the conveying of heavy viscous materials would otherwise be difficult and where temperature control is an important factor. The *Stabilag* jacketing of sight glasses provides a heated cover which prevents crystallisation on the glass.

Available for pilot- and full-scale plant, each jacket is designed for its particular purpose. It can be made to fit the specific contour of the vessel and thus give uniform heat distribution over part or the entire surface, as desired. The power rating of the jacket depends on the physical and temperature requirements of the application and, if these are known, the jacket can be designed to fulfil them. Maximum temperatures are 500 to 700°C., consuming 20 to 30 watts/sq.in. surface area.

### Variable-ratio sample divider for granular materials and powders

One of the major problems of coal analysis is the reduction of the sample taken in the field to a representative sample for laboratory work. From a bulk sample of coal, which in the case of large coal may amount to several hundredweights, it is necessary to prepare a small bottle of powdered coal for analysis. This is usually carried out by crushing and grinding in two or three stages, and sample-dividing, after each stage, to manageable proportions. A generally accepted procedure is as follows. The bulk sample is



Electric resistance heating jacket.

crushed to pass  $\frac{1}{16}$  in. mesh and then reduced to give a sub-sample of not more than 20 lb. This is then ground in one or two stages, sub-dividing at each stage to give a final  $\frac{1}{2}$  lb. laboratory sample of coal through 72 mesh.

With the very large numbers of coal samples now being handled, existing methods of sample-dividing gave rise to several difficulties, either because they were slow and laborious or because they could not cope with direct discharge from a modern, swing-hammer pulveriser without a considerable dust nuisance.

A new sample divider has been designed to overcome these difficulties by Townson & Mercer Ltd. Granular or powdered coal falls by gravity through a duct and is deflected to one side and then to the other by an oscillating chute. The timing of the movement of this member determines the volumetric ratio of the sub-sample separated out. The weight and number of increments can also be controlled by adjusting the rate at which coal is fed through the duct.

The apparatus consists of a duct, rectangular in cross-section, which forks at its lower end into two smaller ducts. Inside the upper part of the duct a small hopper is mounted. A hinged flap is fitted to the outlet of the hopper so that the feed of material may be adjusted.

Just below the hopper, a chute in the shape of a metal vane pivoted about a horizontal axis deflects the falling coal. The chute is activated by two mains-operated solenoids, mounted behind the casing of the duct. The movement of the chute is restricted on either side by means of a stirrup which is fitted on to the hopper outlet. A tapping motion is thus imparted

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to the hopper, ensuring that the material is fed through regularly.

The solenoids are electrically connected to a time-control box, which houses the mechanism for automatically controlling the timing movement of the oscillating chute. This consists of a simple electrical timing circuit, the function of which depends upon the time of charge and discharge of a high-capacity condenser through two variable resistances.

The overall dimensions of the apparatus are approximately as follows: length, 13½ in.; width, 7 in.; depth 7 in. The ranges of operation of the apparatus are as follows: rate of feed—crushed, air-dried coal, 5 to 50 lb./min.; ground coal, down to 2 lb./min.

Although the apparatus was originally designed for sample reduction of coal, it is also suitable for use with other types of freely flowing, granular or powdered materials.

The present method of operating the timing is by means of an *Elcontrol* timer, and the normal timing mechanisms are 0.1 to 5 sec. as originally designed. Longer times have to be arranged specially in the construction of the timer.

### Glass valves and control of corrosive liquids

In search for a material and valve design that would resist the destructive action of hydrochloric acid and isopropyl ether solutions and at the same time afford adequate flow control, two types of glass needle valves have been developed. According to an article in *Industrial and Engineering Chemistry*, March 1952, both are proving satisfactory in small liquid testing operations. The valves, which are only  $\frac{1}{4}$  in. diam., were developed for use in a measuring and purification tower only 1½ in. in diameter. They have replaced costlier metal valves that were found to be unsuitable, and larger glass stopcocks and pinchcocks that had insufficient throttling action for the control of small fluid flows.

The two valves differ from each other in that one operates at a close tolerance, with internal valve parts, and the other operates with no internal valve surfaces rubbing against each other. In the former type, the external parts are machined from *Bakelite*. The glass needle itself is made of ordinary glass, while the lower guiding tube for the needle and the valve body are of a heavy borosilicate glass. Tubing made of flexible *Neoprene* (chloroprene rubber resistant to oils, heat and oxidation) serves as the seal or packing point and forms a tight seal at the stem of the needle and its upper guiding tube. The other valve is similar in general design.

The valve may be used under pressures greater than atmospheric and in cases where transparency is an asset. In tests at an operating pressure of 8 lb./sq.in., no leakage of liquid occurred through the packing or past the seat of the valve when it was closed.



# Chemical Engineering Invention

## MONTHLY SUMMARY OF PATENT CLAIMS

### Counter-current mixer and separator

An apparatus for contacting two immiscible or only partially miscible liquids continuously and in countercurrent, comprises a horizontal or sloping cylindrical tube 1 divided by partitions such as 5 and 6 into a series of alternate mixing spaces 2 and settling spaces 3, the mixing spaces being provided with stirrers 8 mounted on a common spindle 7, each of the two partitions dividing a mixing space from the two adjacent settling spaces being provided with an annular slot such as 9, Fig. 3, the

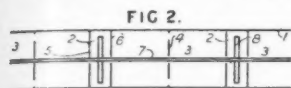


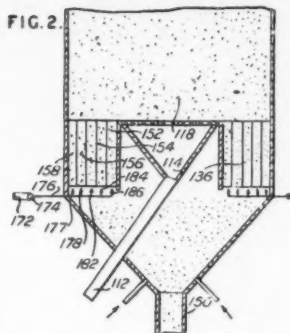
FIG. 3



slots extending along arcs of equal radius concentric with the centre line of the spindle or being adjustable to vary their respective levels so as to vary the net flow of one liquid from one settling space via the mixing space to the other settling space and the corresponding net flow of the other liquid in the opposite direction. Preferably each partition is rotatable in its own plane to vary the level of its slot, and the slots in the two partitions on each side of the same mixing space are fixed with respect to each other in diametrically opposed positions, the slots extending over arcs of 120° or less. The partitions may be fixed to the tube so that they can be turned together with the latter, the tube bearing a pointer which moves along a scale to indicate their position. The settling in the spaces 3 is assisted by partitions 4 provided with slots and perforations in their top and bottom sections. Specification 486,347 is referred to.—617,626, *N.V. de Bataafsche Petroleum-Maatschappij*.

### Stripping fluidised catalysts

In stripping strippable materials from finely-divided fluidised solids, the solids are withdrawn directly from a dense fluidised bed and passed through an annular stripping zone in countercurrent to a stripping gas. Baffle means, comprising vertical plates or partitions, which serve to divide the stripping zone into a plurality of vertical sections, are provided, whereby the path of the solid therethrough is broken up into a plurality of separate paths. The process may be used to remove combustible vapours from spent catalyst particles which have been used in a hydrocarbon cracking or conversion, e.g. in the cracking of crude, reduced crude, gas oil or naphtha using acid-treated clay, silica-alumina gel or silica-magnesia gel 200 to 400 mesh particles as catalyst at temperatures of 700° to 1,100° F. The



stripping gas may be carbon dioxide, nitrogen, recycle gas or normally gaseous hydrocarbons, but is preferably steam. In one form of apparatus, Fig. 2, spent contaminated catalyst particles are withdrawn from a bed 118 and are passed through an annular stripping zone 136 which is subdivided into a plurality of annular sections by vertical concentric walls 152, 154, 156, 158 and is further sub-divided by vertically-disposed radial plates or baffles (not shown), stripping gas being fed by a line 172 through an annular manifold 174, and through a plurality of nozzles 177, 178, 182, 184, 186. The stripped fluidised catalyst particles pass to a standpipe 150, are sent to a regeneration zone (not shown) for burning off carbon, and are then returned to the reaction vessel through a line 112 and flared funnel 114. In another form of apparatus (Fig. 4, not shown) vertical radial plates or baffles only are provided. In a further modification, Fig. 7, the annular stripping zone is divided by a cylindrical baffle 368 into two smaller annular sections, each of which is provided with a series of 'doughnut' constructions such as 376, 388, below each of which is arranged a disc baffle such as 392 of triangular cross section. The stripping gas is supplied through nozzles 354, 356. Preferably the sections have a ratio of length to effective diameter (*i.e.* four times their area divided by the perimeter) of not less than four and preferably six to 20. The preferred maximum flow rate of the catalyst through the zone is given by the expression:

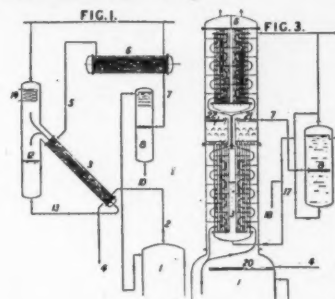
$$\frac{1920}{V^{1.36}} \text{ lb./min./sq. ft., } V \text{ ft./sec.}$$

being the upward velocity of the stripping gas.—612,815, *J. C. Arnold (Standard Oil Development Co.)*.

### Distilling immiscible and partially miscible liquids

A pure component is separated from the vapours evolved in the distillation of mixtures of two immiscible or partially

miscible liquids by subjecting the vapours to primary condensation by means of the cooling action of a liquid having a boiling temperature equal to, or nearly equal to, the dew point of the particular vapour mixture (referred to as 'the eutectic') which, for a given pair of such liquids, has the minimum dew point.



The vapours produced in distillation tower 1, Fig. 1, pass through pipe 2 into tubular bundle 3 where they are indirectly cooled by a liquid having a boiling point a few degrees lower than the dew point of the eutectic. The condensate from this primary condenser is withdrawn through pipe 4, and the eutectic passes out through pipe 5 into secondary condenser 6. The condensate from the latter flows into decanter 8 where it separates into two layers, one of which is returned to the tower as reflux, while the other is withdrawn from the system through pipe 10.

The vapours of the cooling medium, evolved from bundle 3, are condensed in receiver 12 by means of auxiliary condenser 14, the condensate being recirculated to the bundle through pipe 13. The pressure may be modified, if desired, either in the cooling circuit or in 'the cooled circuit.' Some of the condensate of the eutectic itself may be used, either as an emulsion, or by decanting and employing the component of lower boiling point only, as the cooling liquid. The auxiliary condenser 14 is then unnecessary. The top of column 1, Fig. 3, contains both the primary condenser 3 and the secondary condenser 6, connected as shown; and the secondary condensate, collected on plate 21, is passed through pipe 7 to decanter 8 from which the lower liquid layer is sent, through line 17, to act as cooling liquid in primary condenser 3, any excess liquid being withdrawn through pipe 18.

The vapours from this cooling liquid rise through space 22, mix with the eutectic, and are condensed therewith in bundle 6. The primary condensate is collected on plate 20, and withdrawn through pipe 4. The method may be used to separate mineral oil from steam, and also for solvent recovery.—618,419, *Compagnie Francaise de Raffinage*.

# World News

## GREAT BRITAIN

### Cement chemistry conference

Some 23 papers on different aspects of the chemistry of cement were given by speakers from the U.K., U.S.A., France, Italy, Canada, Germany, Switzerland and Denmark at the Third International Symposium on the Chemistry of Cement held in London in September. It was sponsored by the D.S.I.R. and the Cement and Concrete Association. Delegates visited the Building Research Station at Watford, the research station of the Cement and Concrete Association at Stoke Poges, the laboratories of Birkbeck College, London University, the research laboratories of the Associated Portland Cement Manufacturers Ltd., and a cement works.

### Course on nuclear reactors

A series of 30 lectures on nuclear reactors is being given at the Imperial College of Science and Technology, London, on Friday afternoons at 4.30 p.m. during the 1952-3 session from October 10. By permission of Sir John Cockcroft, Director of the Atomic Energy Research Establishment, Harwell, the lectures are to be given by members of his staff. The lectures will be divided into three groups.

The first group of 12 lectures will be concerned with slow neutron natural uranium reactors and will conclude by way of example with a detailed description of the large pile at Harwell (known as BEPO). The earlier lectures in this series will deal with the elementary nuclear physics appropriate to slow reactors and these will be followed by the application of such knowledge to the design and control of a simple graphite-moderated reactor.

Secondly, a group of six lectures will deal with particular aspects of reactors of various types. The lectures will contain information on the various possible systems and a discussion of the problems involved in metallurgy, chemistry, engineering, heat transfer and physics. There will be one lecture on health physics in this group.

The third group will consist of three specialised courses.

For mathematicians there will be five lectures on more advanced slow and fast neutron theory. For engineers there will be five lectures on heat transfer and reactor design. For physicists there will be one lecture on the experimental use of a reactor followed by the opportunity to take part in experiments involving neutron diffusion and the measurement of a neutron flux.

At the conclusion of the course it is hoped to arrange a visit to Harwell to inspect the Harwell piles and give an opportunity for informal discussion with the various lecturers. The fee for attendance at the whole of the lectures is 10 guineas. An appropriate reduction in fee is allowed

for those who may wish to attend only a selected part of the course. Students of the College and inter-collegiate students are admitted free, the latter on production of an inter-collegiate ticket.

### No sulphur plant at Shellhaven

The Shell Company inform us that, contrary to the statement on p. 479 of our September issue, there are no plans for building a sulphur recovery plant at Shellhaven refinery. We apologise to the company for this error.

### Visits to U.S. factories

A number of business men have arrived in the U.S.A. during recent weeks wishing to visit installations of the U.S. Department of Defence and other Government laboratories and installations. In some cases their itineraries have been delayed because sufficient notice to enable the necessary clearances to be obtained from the U.S. Government Department concerned has not been given to the Commercial Department of the British Embassy in Washington.

Business men wishing to visit such installations and laboratories are advised to inform the Commercial Relations and Exports Department (Industries Branch) of the Board of Trade, Horse Guards Avenue, London, S.W.1.

## HUNGARY

### Hungarian-Rumanian chemical enterprise

Hungary and Rumania are establishing a joint chemicals manufacturing company, 'Romagchim.' A new factory is being built in Hungary which will be fuelled by natural gas piped from Rumania. A second and bigger factory is being erected in Rumania. Hungary is supplying machinery and other equipment for the chemical factories, in particular for soda ash production in Rumania.

## SWITZERLAND

### Chemical warning labels

The International Labour Office has proposed a standardised world system of labelling dangerous substances to avoid accidents in handling them.

Simple but strikingly designed wordless labels in white and orange would be used so that even illiterate workers could understand them. Proposals for label designs include an exploding grenade for explosive substances, a lighted match for inflammable substances, a skull for toxic substances, a corroded hand for corrosive substances and a skull and crossbones against a radiant 'R' for radio-active substances.

The proposals were considered at an I.L.O. Chemical Industries Committee meeting held last month in Geneva.

## SPAIN

### Ammonium sulphate plant to be built

Following suggestions from the Spanish Government, Sociedad Anonima Altos Hornos de Vizcaya has agreed to build a fertiliser plant at Sagunto to use coke-gas residues from blast furnaces there. The factory is expected to produce 60,000 metric tons p.a. of ammonium sulphate.

### Refinery capacity enlarged

New equipment recently installed in the Escombreras oil refinery (Carthagena) is now in operation. It is estimated that this new unit will increase refining to some 1.3 million tons p.a. of crude oil.

### Sulphuric acid production raised

The monthly average production of sulphuric acid during the first quarter of 1952 was 69,000 tons, compared with 58,471 in 1951 and 30,581 in 1947. This shows a 30% rise in capacity during the past three years. Productos Quimicos Ibericos, Almeria, is to install new equipment for the production of sulphuric acid under a Spanish patent to raise output to 30 tons/day.

## SWEDEN

### New H<sub>2</sub>SO<sub>4</sub> plant

Bolidens A.B., of Sweden will build a sulphuric acid plant at Ronnskar, an island near Skelleftehamn on the Gulf of Bothnia, where the firm has smelters and can use the by-product sulphur dioxide gases as the raw material. The new plant is expected to produce 30,000 metric tons p.a. of sulphuric acid.

## DENMARK

### Manganese sulphate plant

A new plant for the production of manganese sulphate from bog ore is to be set up at Bolderslev, Southern Jutland. The initial capacity of the plant will be around 1,000 tons p.a., or double Denmark's annual consumption of this compound. Supplies of bog ore are estimated to contain sufficient high-grade material to cover 15 years' production. To conserve these deposits for the new plant, the Government earlier this year banned all exports of ore with a manganese content of over 10%.

The low-grade ore is being exported mainly to Germany. In 1951, some 30,000 tons were shipped abroad.

## GERMANY

### Deep mining of potash

Expansion of the Burbach Potash Works at Wolfenbüttel, near Brunswick, has been completed and the company's next aim is to achieve economies by introducing modern deep-mining methods. Annual production capacity now amounts to 400m. kg. of potash, compared with 188m. kg. in 1951 and 65m. kg. in 1948.

## YUGOSLAVIA

### New aluminium factory

Machinery is now being installed at a large, new, aluminium factory situated in the vicinity of substantial bauxite deposits at Razine near Sibenak on the Dalmatian coast. The factory, with its 30,000 sq. m. of floor space, is scheduled to be completed by the end of this year. A rolling mill, also at Razine, is due to start production in the middle of 1953.

## FRANCE

### Barbet's new venture

An agreement has recently been reached between R. S. Aries & Associates, New York chemical engineers, and Etablissements Barbet, one of the oldest French process engineering, equipment and construction companies, whereby Aries services, including the acquisition of processes and the setting up of complete installations, will be extended in France and the French Union. A similar arrangement was made earlier this year between Aries and Barbet Ltd., London (see *CHEMICAL & PROCESS ENGINEERING*, June 1952, p. 327).

## NORWAY

### Norsk Hydro expansion plans

Following negotiations with the Norwegian Government, Norsk Hydro is to start work immediately on extensions to its ammonia plant at Glomfjord and Heroya. This will increase ammonia capacity to 8,000 tons p.a. Cost of the work is estimated at 22 million kroner. A new acid factory is also to be built at Heroya; it will cost 4 million kroner and will have a capacity of 2,000 tons p.a. A new fertiliser factory is to be built at Heroya and will cost 30 million kroner.

Plans are also in hand for a further extension of the company's nitrogen production by expanding the electrolysis plant at the Rjukan salt-petre factory. The firm is also working on plans for building a new factory for electrothermal phosphorus, and a new hydro-electric plant, in N. Norway. Total cost of these projects is estimated at 98 million kroner, but all the work has not yet been approved. The firm is accordingly earmarking only 50 million kroner for the time being. The phosphorus plant would have a total capacity of 8,700 tons p.a.

## TURKEY

### Starch factory project

American assistance in building and operating a plant to produce starch, glucose and by-products, is being sought by Mr. Salih Coroglu, of Kocaali Yag Fabrikasi, Adapazari. A plant having a production capacity of 10 tons/day of starch is envisaged. Supplies of raw materials are available locally. An initial survey shows there is a good market for starch and glucose in Turkey which has no important producer of these products at present.

## ITALY

### Atomic energy in industry

A Nuclear Research Committee has been set up in Italy, under the presidency of Prof. Francesco Giordani. The committee is charged with co-ordinating nuclear research and the employment of atomic energy in industry. As a beginning it has been endowed with a fund of 1 milliard lire.

### More methane for industry

The use of methane by Italian industry, at present about  $4\frac{1}{2}$  million cu.m./day, will rise to 8 million cu.m./day at the end of the year and more than 10 million cu.m. in 1953 if the Government's plans are carried out.

Production of electric power continues to increase. A few months ago the new 700 million kwh. thermo-electric station was opened at Tavazzano. It operates on methane.

It is also reported that the Fiat company intend to run all their plants exclusively on natural gas instead of coal. The switch is being made possible by the opening of the new methane pipeline from Cortemaggiore to Turin. The line is 210 km. long and has a capacity of  $3\frac{1}{2}$  million cu.m./day of gas.

## CYPRUS

### British machinery for cement factory

Work will start this month on the construction of a large cement factory which is expected to produce 100,000 tons of high-quality Portland cement p.a. The Cyprus Cement Co., with a capital of £1 million, has purchased a site near Limassol; plans for the factory are ready and machinery has been ordered from Britain.

Annual production of the factory will be sufficient to cover local needs, estimated now at some 50,000 tons p.a., and also to provide another 50,000 tons for export.

The company was registered in January this year as a private company and shares have not been offered to the public. Most of the capital is understood to be British in origin. Among the company's declared objects is to prospect, explore and develop asbestos, petroleum and other minerals.

Some months ago a new factory started production of plasterboard on the island, using locally-quarried gypsum (see *CHEMICAL & PROCESS ENGINEERING*, 1952, 33, (5), 267).

## JAMAICA

### Dolomite found

The Geological Survey Department has discovered in several places deposits of dolomite, a carbonate of lime and magnesium mainly used in making linings for steel furnaces. The deposits, not previously known to exist there, are expected to run into millions of tons.

## SOUTH AFRICA

### Vitamin oils exported

About two months ago the Union's first bulk export of fish oil—about 1,000 tons—was pumped into a liner's deep tanks for Rotterdam, the five pipelines used giving a peak delivery of 100 tons in 30 min. Another bulk shipment of 1,000 tons followed a month later.

The distribution and chemical analysis of the fish-oil industry's output is handled by the Marine Oil Refiners of Africa Ltd., who have a £750,000 factory in Dido valley, Simonstown. This firm is itself the largest single user of fish oil in S. Africa.

This year it is using more than 7,000 tons of the total allocation of fish oil to S. African industries.

In June this year the company expanded by completing its new £150,000 oil segregation plant, which trebles the factory's oil segregation capacity and polymerisation and refining equipment. When this firm bought the first *Solexol* segregation plant made, even American manufacturers thought it would be unwise to use the plant to segregate fish oils. The installation proved eminently satisfactory, and it is the only such plant in use outside America.

The factory's main business is producing industrial and edible oils from pilchard oil, but it also makes vitamin A from shark and hake livers and processes sunflower and castor oils for industrial uses. Earlier it concerned itself mainly with the vitamin A concentrates.

From 1943 to 1948 S. Africa supplied the whole of Britain's requirements of vitamin A from fish livers, but with the advent of synthetic vitamin A prices slumped.

Vitamin A concentrates from the Cape are still exported to many parts of the world. The factory holds the whole contract for a Netherlands margarine firm.

## SOUTHERN RHODESIA

### Asbestos mining project

The Johns-Manville Corporation, which operates two asbestos mines in Canada, has announced plans for immediate development in Rhodesia of a third asbestos mine. The cost of the undertaking and its eventual capacity were not disclosed.

The new project calls for development of the asbestos ore properties of Rhodesian Asbestos Ltd. at Mashaba, in the Victoria district of S. Rhodesia, about 200 miles south of Salisbury and 120 miles east of Bulawayo.

Rhodesian Asbestos Ltd. was formed in December 1951 and is under the direction of Canadian Johns-Manville Co., Ltd., a subsidiary of the American Corporation in association with British Metals Corp., Ltd., Anglo-Huronian Ltd., Southern Minerals and Marketing Corp. Pty. Ltd., and the Simon I. Patino interests.



## INDIA

### Oil refinery contract

The Standard Vacuum Oil Company's 25,000 barrel/day crude oil refinery in Bombay is to be constructed by the Lummus Co. of America. Field survey work has already begun.

Besides Standard Vacuum's \$35 million project, Burma Shell is also erecting a refinery in Bombay under agreement with the Indian Government. Both are expected to go into production early in 1955.

### Phosphate fertiliser trials

The Engineering Section of the National Chemical Laboratory at Poona, is conducting experiments on the production of certain types of phosphatic fertilisers not yet manufactured in the country, using phosphate rock from Trichinopoly. These experiments will determine conditions for commercial manufacture.

A plant is being assembled for production of phosphorus and its processing into triple superphosphate.

## PAKISTAN

### To much sodium silicate

The capacity of Pakistan's 16 chemical factories producing sodium silicate is said to be 52,000 tons p.a., but only 15,450 tons p.a. are actually being produced. Pakistani manufacturers have thus asked for drastic cuts in imports of sodium silicate which, over the last four years, have averaged 12,050 tons p.a. Chief suppliers are India, the U.K. and Holland.

### New caustic soda and fertiliser plants

Plant and machinery for a caustic soda project to be set up at Nowshera by the Pakistan Industrial Development Corporation have been ordered. The scheme will be completed in 1954 and will cost Rs.2,600,000.

The Corporation is taking steps to set up a fertiliser plant near Daudkhel in Mianwali, Punjab. It will cost nearly Rs.50 million, and produce nearly 50,000 tons of ammonium sulphate, and go into production by the end of 1955.

## JAPAN

### Fertiliser target nearly 4 million tons

Production of nitrogenous fertiliser in Japan during the 1951-52 fertiliser year (August-July) totalled 2,318,000 metric tons, including 1,760,000 tons of ammonium sulphate, according to the Japanese Ministry of International Trade and Industry. The figure compared with 2,072,000 tons, including 1,571,000 tons of ammonium sulphate, in the preceding fertiliser year. It also was above the target, which was 2,290,000 tons.

The Ministry said exports of nitrogenous fertiliser from Japan during the 1951-52 fertiliser year amounted to 181,286 tons, including 171,241 tons of ammonium sul-

phate and 4,637 tons of calcium cyanamide. The principal destinations for ammonium sulphate were (in metric tons):

Korea	..	..	..	78,566
Formosa	..	..	..	64,708
Philippines	..	..	..	11,300
India	..	..	..	10,667
Okinawa	..	..	..	5,800
Siam	..	..	..	200
Total	..	..	..	171,241

Production of phosphate fertiliser during 1951-52 totalled 1,670,000 tons, including 1,390,000 tons of superphosphate of lime. This was slightly short of the target of 1,700,000 tons. Exports of phosphate fertiliser totalled 54,481 tons, including 52,600 tons of superphosphate of lime. Korea took 50,000 tons of superphosphate of lime and Okinawa 2,600 tons.

Exports during 1950-51 totalled 232,000 tons of nitrogenous fertiliser and 5,000 tons of phosphate fertiliser.

The Ministry of International Trade has set production targets for the 1952-53 fertiliser year at 2.4 million tons of nitrogenous fertiliser and 1.5 million tons of phosphate fertiliser. Export targets are 550,000 tons and 100,000 tons respectively.

## QATAR

### Revised oil agreement

Petroleum Development (Qatar) Ltd., an associated company of the Iraq Petroleum Co. Ltd., has concluded negotiations with the Shaikh of Qatar for the modification of their concession, to introduce the 50-50 principle now generally established in the Middle East. Under the modified concession, the Ruler, Shaikh Ali bin Abdullah bin Jasim al Thani will receive half the profits accruing from the operations of the company in his territory, instead of a fixed royalty as provided in the original concession.

The original concession was granted by Shaikh Abdullah bin Jasim al Thani, father of the present Ruler, on May 17, 1935, giving to the company the exclusive right to search for, extract and export, petroleum and natural gas for a period of 75 years and covering the whole of the Shaikh's domain. After geological exploration, a test well was located on the Dukhan structure near the western shore of the peninsular in October 1938, and was completed in January 1940 at a depth of approximately 5,000 ft. where it gave an estimated initial production of 5,000 barrels/day of oil. Two more wells were drilled before operations were suspended for the duration of the war in 1942. Operations were resumed in 1947 and the production of oil commenced in December 1949.

Production in 1950 and 1951 totalled respectively 1.7 million tons and 2.3 million tons and is now running at 3 million tons p.a.

## URUGUAY

### Cement plant required

The Administracion Nacional de Combustibles, Alcohol y Portland, Casilla de Correo 1,090, Montevideo, is reported to be planning the construction of a Portland cement plant with a minimum annual output capacity of 90,000 metric tons. It is understood that they are to invest about 10,000,000 pesos in this plant which will be designed to permit output capacity to be doubled simply by the addition of machinery and equipment.

The organisation wish to purchase complete machinery, equipment and accessories for the plant and tenders covering this procurement are invited.

## ECUADOR

### Sulphur for export

The Tixan sulphur mines, operated by the Ecuadorian Mining Co. on behalf of the Chemical Plants Corporation of New York, are satisfying local needs and even providing a small amount for export. The New York company has a contract for the exploitation of these sulphur deposits for 20 years.

Ecuadorian Mining Co., meanwhile, has been granted a concession to prospect for sulphur over a further area of 1,000 sq. miles. It is also reported that there are valuable sulphur deposits in the States of Carchi and Cotopaxi and in the Galapagos Islands.

## ARGENTINE

### Fish-meal factory

A new factory for the production of fish meal, the first of its type in Argentina and the third in S. America, has been inaugurated at Mar del Plata, the country's principal fishing port. It is equipped with American machinery and has a capacity to handle 5 tons/hr. of fish, 105 tons/day in three 7-hr. shifts, or 2,600 cases of fish daily. The U.S. is willing to take all the fish meal the factory can supply, while the U.K. has placed an initial order for 1,000 tons, and Brazil wants 100 tons/month.

## MEXICO

### New aluminium plant

An aluminium processing plant is to be built in the valley of the Papaloapan River, at an initial cost of 100 million pesos. The plant will be located in the region of the Presidente Aleman Dam, where the hydro-electric station, now under construction, will produce 100,000 kw. of electric power. The plant will lead to a reduction in Mexican imports of aluminium products and semi-finished aluminium and also to an increase in exports, chiefly to other Latin American countries, of goods made of the metal.

Mexico's only deposits of aluminium ore are in the central State of Guanajuato. They are extensive and contain about 2

million metric tons of alunite, but the ore is lacking in colour consistency and is not found in a pure form. The deposit was worked spasmodically during the 1930s but production has never exceeded the 1933 figure of 918 kg.

Imports of aluminium in 1951 amounted to 660 metric tons valued at 3,090,400 pesos, far in excess of any previous year. Mexican exports of aluminium manufactures in 1951 were 105 tons, worth 985,559 pesos.

### Large sulphur find

The discovery of what may be one of the world's largest volcanic and almost pure sulphur deposits has been reported. The deposit, of 95% purity, is located in the crater of a volcanic hill 3,000 ft. high on Socorro Island in the Revilla Gigedo group 370 miles off the west Mexican Pacific coast. Mr. Joseph Wekstein, who shares a federal reserve concession, said he expected the delivery of 1,000 tons of ore and 200 tons of refined sulphur a day nine months after mining operations begin. A road five miles long and loading facilities would have to be built.

Present production of sulphur in Mexico is less than 200 tons/day.

## BELGIAN CONGO

### Petrol-from-coal studies

Two years ago the Syndicat d'Etudes de Charbons de la Lukuga was formed to investigate the nature of the oil extract to be obtained from the Lukuga coal deposits exploited by the Société Geomines, and to look into the possibility of using this for the manufacture of synthetic fuels. The Syndicat des Charbons de la Lukuga has continued these investigations and is at present experimenting on the gasification of the coal.

### New oil pipeline

Work on the new oil pipeline from Anglo-Ango to Leopoldville, which began

towards the end of last year, is proceeding to plan, and the first 50 km. of pipeline have been completed. When the whole is finished at the beginning of 1953 it is expected to deliver petroleum at the rate of 1.5 million l./day, and the installation of further additional storage tanks at Leopoldville is under consideration. During 1951, the Anglo-Ango installations forwarded through Leopoldville to the interior approximately 300 million l. of spirit, petroleum and gas oil.

## CANADA

### New process engineering company

A new company, Dominion, Scott, Barron, Ltd., has been formed in Canada. Half of the capital is Canadian and the other half British, the Balfour Group having 30% of the latter and W. S. Barron & Son, Ltd., 20%. Dominion Wheel & Foundries Ltd., a branch of Canada Ironfoundries, represent the Canadian interest. Under the aegis of the new company, Henry Balfour & Co., Ltd., George Scott & Son (London) Ltd., Ernest Scott & Co., Ltd., and W. S. Barron & Son, Ltd., will extend their operations in Canada and U.S.A.

Mr. W. Lindsay Burns, recently appointed chairman of the Balfour Group, visited Canada and U.S.A. to complete the arrangements for the new company. Two British directors will go to Canada for a time. They are Mr. H. D. Macmurray (Balfour) and Mr. W. H. Moreland (Barron).

### Development of sulphur production

The development of Canadian sources of sulphur is making good progress, officials report. Since the turn of the year, two plants processing natural gas, each with a capacity of 9,000 long tons p.a., have been brought into production by Royalite Oil and Shell Oil. The Noranda Mines concern is reported to be planning the setting up of a plant at Welland, Ontario, with an

output of around 20,000 tons of sulphur and sulphur dioxide p.a. The Aluminium Co. of Canada has increased the sulphuric acid capacity of its Arvida, Quebec, plant by 35,000 short tons p.a., while the Nichols Chemical Co. has doubled output at its Valleyfield, Quebec, plant.

### New paper chemicals plant

A new caustic soda, sodium sulphite, chlorine and hydrochloric acid plant costing \$3 million is to go into production shortly at Marathon, Ontario. The plant is under construction for the Marathon Paper Mills of Canada Ltd., and will provide chemicals required in the production of high-grade bleached sulphite pulp.

## UNITED STATES

### New asbestos plant planned

The U.S. Defence Materials Procurement Agency, buyer of foreign and domestic metals and minerals, has made preliminary arrangements to buy and process crysotile asbestos from independent producers in Arizona. The Administrator of the Agency said that there were many known deposits of very high grade crysotile asbestos in Arizona. It was hoped that the new programme would increase production from known deposits and speed up the search for other deposits. The U.S. is almost wholly dependent on foreign sources for high grade, long-fibre, low-iron asbestos, which is known to exist in Arizona.

A plant which is to be built by the Agency will treat any raw asbestos to meet specifications of the national stockpile and industrial requirements. The Agency has earmarked funds for up to 5,000 tons of No. 1 spinning grade crysotile asbestos and 35,000 tons of commercial grade asbestos.

### Cheaper drying process

Scientists of the Armour Research Foundation, Illinois Institute of Technology, have developed a new drying method based on sulphur dichloride vapour. The process is claimed to take between 2 and 20 sec. to complete, depending on the ink, paint or varnish used and the material coated—paper, cloth, metal, wood, glass or plastics.

### Amphibious sulphur plant

At Grande Ecaille, Louisiana, an amphibious mining plant, designed to extract sulphur from submerged domes by means of the Frasch process, has been constructed for operation at Bay Ste. Elaine. The plant is expected to start operating this month. The area is mainly swampy islands.

Official estimates of U.S. production of sulphur for the second half of this year are 3% higher than the estimated production in the first half. This increased production is not likely to have much effect on world availability of sulphur as U.S. demands, although restricted by means of

## The Leonard Hill Technical Group

Articles published in some of our associate journals in the Leonard Hill Technical Group this month include:

**Manufacturing Chemist**—Artificial Essential Oils; Cinnamon Oil Analysis; Cosmetic Research in America; Progress Reports on Chemotherapy, Cosmetics and Fertilisers.

**Food Manufacture**—Lecithin in Food Processing, Part IV; The Chemistry and Physics of Macaroni Products, Part III; Soya-Staple or Substitute.

**Building Digest**—Concrete Floor Construction.

**Pottery and Glass**—Domestic Pottery Today; Galaxy of Glass.

**World Crops**—Drift Spraying; The Correct Use of the Low Volume Mist Blower; The Murphy Chemical Co.

**Petroleum**—The Sulphur Prospect; Pipelines in France.

**Atomics**—Recent Gamma Radiography Applications; The Brookhaven Cosmotron; Atomic Energy Control in Britain.

**Muck Shifter**—Recent Developments in Concrete Road Construction; Largest Italian Power Station; New Giant Tyre.

an Order, are rising in proportion to domestic production.

In order to meet the need for increased sulphur production certain mining companies are forced, for technical reasons, to use methods other than the Frasch process to mine sulphur. In many cases this involves heavier production costs. The Office of Price Stabilisation, therefore,

announced on July 1 that special price ceilings will be set for firms mining sulphur by non-Frasch methods who export their products. No general ceiling will be established, but ceilings will be set for individual firms. It is expected that most of this sulphur will find its way on to the export market and will not, therefore, affect the domestic price.

## MEETINGS

### Chemical Society

October 7. 'The Winning and Utilisation of Peat,' by A. J. Howard, 7.15 p.m., Department of Agricultural Chemistry, Queen's University, Belfast. Joint meeting with the Royal Institute of Chemistry and the Society of Chemical Industry.

October 22. 'Physical Chemical Methods in Sugar Industry Laboratories,' by R. J. P. Carolan, 7.45 p.m., University College, Upper Merrion Street, Dublin. Joint meeting with the Institute of Chemistry, Ireland.

October 24. 'Applications of Spectroscopy to Chemical Problems,' by Dr. W. C. Price, 7.30 p.m., Robert Gordon's Technical College, Aberdeen. Joint meeting with the Royal Institute of Chemistry and the Society of Chemical Industry.

October 24. 'Some Unusual Applications of Surface-active Agents,' by J. L. Moillett, 5 p.m., Washington Singer Laboratories, Prince of Wales Road, Exeter. Joint meeting with the Society of Chemical Industry.

October 24. 'Atoms in Cages,' by H. M. Powell, 5 p.m., New Chemistry Building, The University, Southampton. Joint meeting with the University Chemical Society.

October 28. 'Detergent Action,' by Prof. N. K. Adam, 6.30 p.m., Department of Chemistry, The University, Leeds.

October 31. 'Chemical Research at Harwell,' by Dr. R. Spence, 5.30 p.m., Chemistry Department, University Col-

lege, Swansea. Joint meeting with the University College Chemical Society and the Royal Institute of Chemistry.

November 13. 'Some Recent Progress in Natural Product Research,' by Dr. D. H. R. Barton, 7.30 p.m., Chemistry Lecture Theatre, The University, Sheffield. Joint meeting with the University Chemical Society.

### Institute of Metal Finishing

October 20. 'Tin/Nickel Alloy and Nickel/Chromium Coatings: Some Comparative Corrosion Tests,' by S. C. Britton and R. M. Angles. 'Tin/Nickel Alloy Coatings: Methods of Testing Thickness and Porosity,' by S. C. Britton and D. G. Michael. Joint meeting with the Corrosion Group of the Society of Chemical Industry.

November 4. Symposium, 'Low Cost—High Productivity in Metal Finishing.'

### Society of Chemical Industry

#### FOOD GROUP

October 29. 'Some Aspects of Education in Food Technology,' by Dr. J. D. Mountfield, London.

October 30. 'The Work of the Food Investigation Organisation,' by Dr. E. C. Bate-Smith, Bristol.

### Incorporated Plant Engineers

October 7. 'Fire Protection in Factories and Works,' by G. W. Underdown, 7

p.m., Royal Society of Arts, John Adam Street, London, W.C.2.

October 8. 'Protecting your Plant from Fire,' by J. C. Elliott, 7 p.m., Welbeck Hotel, Nottingham.

October 9. 'Manufacture of Glass and Some Aspects of Toughened Glass,' by D. Curran, 7 p.m., Royal Society of Arts, John Adam Street, London, W.C.2.

October 21. 'Manipulation of Corrosion and Heat-Resisting Steels,' by J. A. McWilliam, 7 p.m., Engineering Centre, 351 Sauchiehall Street, Glasgow, Scotland.

October 22. 'The Application of the Gas Turbine in Industry,' by A. W. Pope, 7.15 p.m., Grand Hotel, Bristol.

### Institute of Fuel

October 28-29. Conference, 'Ash and Clinker in Industry.' Papers: Tuesday, 'Origin and Nature of Ash; Sampling and Analysis,' by J. L. Edgcombe and Dr. A. B. Manning; 'Cleaning of Coal,' by A. Grounds and A. M. Wandless; 'Clinker in Practice—Handling and Disposal,' by W. G. Marskell and C. W. Pratt; 'External Boiler Deposits,' by Dr. H. E. Crossley; 'Design of Plant as Affected by Ash,' by W. F. Simonson. Wednesday, 'Ash and Boiler Efficiency,' by Dr. A. C. Dunningham; 'Recent Work by the B.C.U.R.A. on the Effect of Ash upon the Performance of Shell Boilers,' by E. J. C. MacDonald and M. V. Murray; 'Utilisation of High-Ash Coals,' by F. B. Karthauser; 'Ash and Atmospheric Pollution,' by A. Fitton; 'The Influence of Ash on the Operation of Gas Producers in the Gas Industry,' by L. G. Townsend; 'Gas Turbines,' by T. F. Hurley.

### Institute of Physics

October 24-25. X-ray Diffraction Anniversary. Friday, 'Historical Survey,' by Prof. Sir Lawrence Bragg; 'The Growth and Scope of x-ray Crystal Analysis,' by Prof. J. D. Bernal. Saturday, 'Chemical Problems,' by Dr. D. Hodgkin, F.R.S.; 'X-ray Analysis and the Metallic State,' by Prof. G. V. Raynor; 'The Application of x-ray Analysis to Protein Structure,' by Prof. Sir Lawrence Bragg.

### Institute of Petroleum

October 8. 'Methods of Atomising Liquid Fuels,' by J. R. Joyce, 5.30 p.m., 26 Portland Place, London, W.1.

October 22. 'Distribution of Petroleum in the U.K.—The Changing Pattern,' by T. W. Mathias, 5.30 p.m., 26 Portland Place, London, W.1.

### Institution of the Rubber Industry

October 20. 'Commercial Development of Butyl,' by Dr. E. J. Buckler, Polymer Corporation Ltd., Sania, 6 p.m., Institution of Electrical Engineers, Savoy Place, London, W.C.2.

October 27. 'Low-Temperature Properties of Polymer Plasticiser Systems,' by Dr. E. J. Buckler, Manchester. The paper will also be read at Glasgow on October 29.

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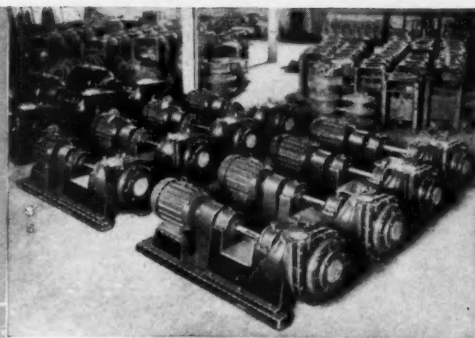
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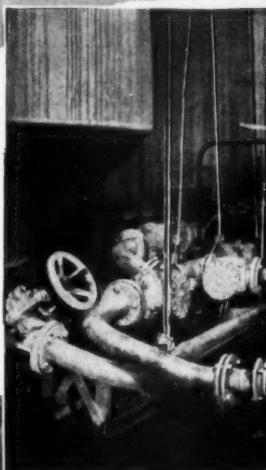
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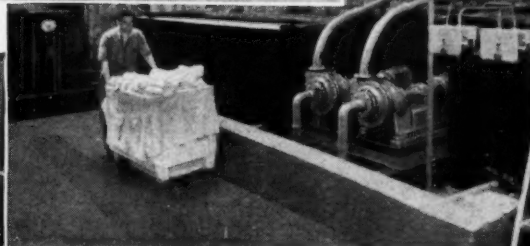
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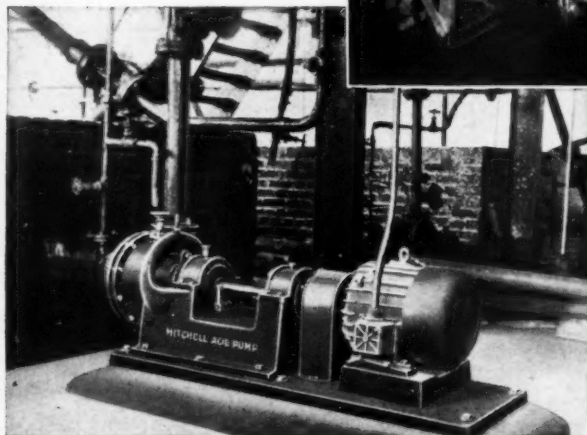
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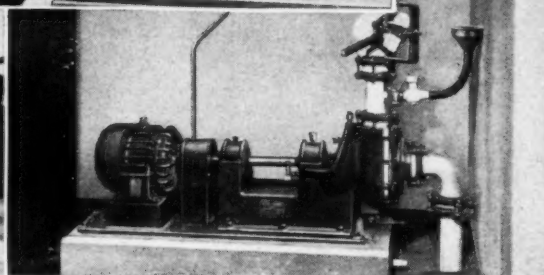
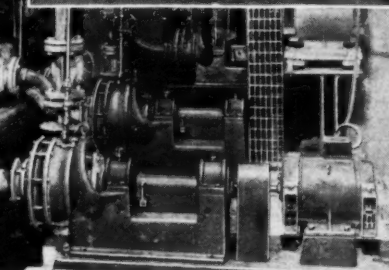
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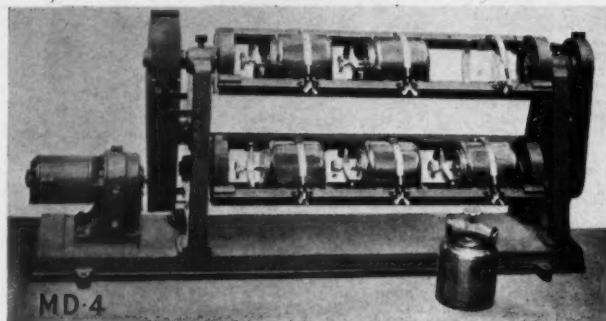
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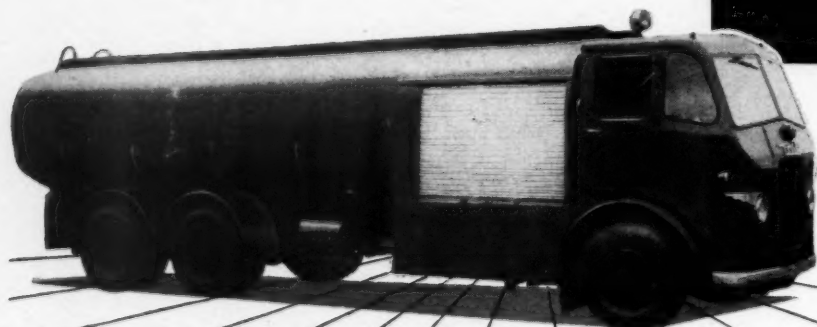
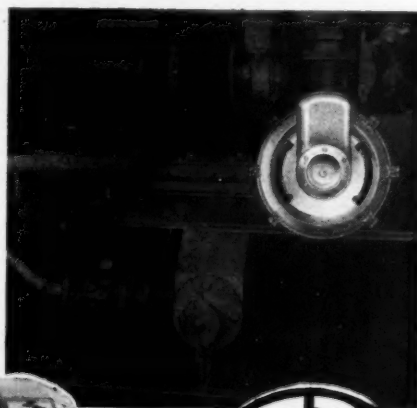


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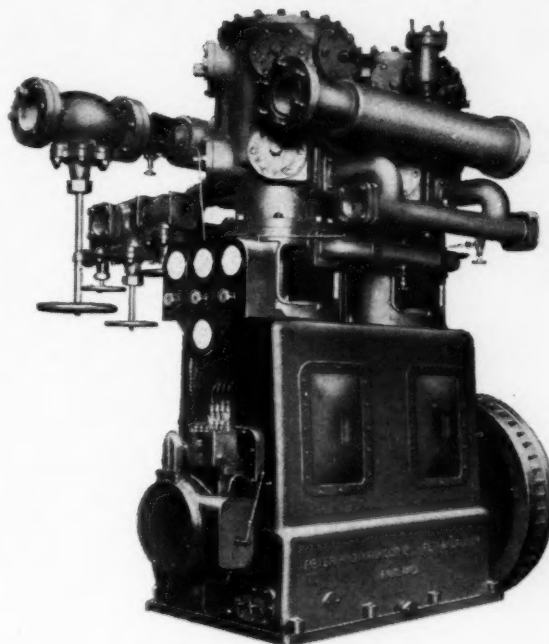
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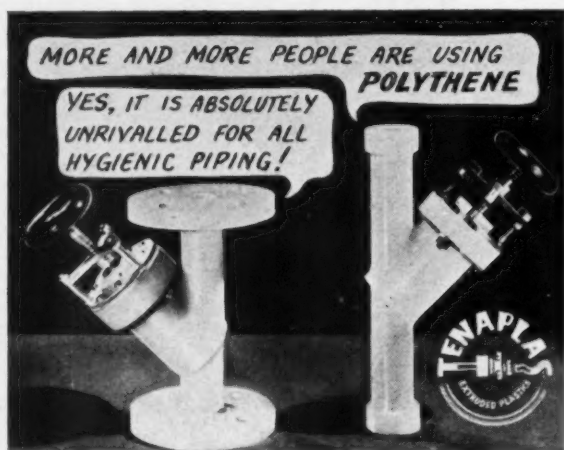
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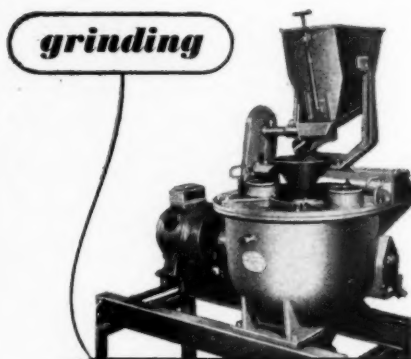
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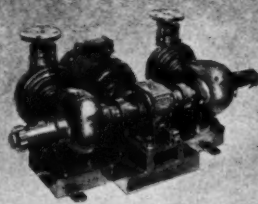
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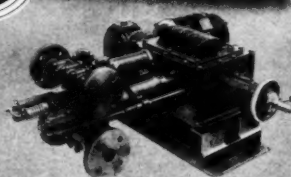
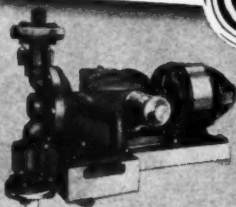
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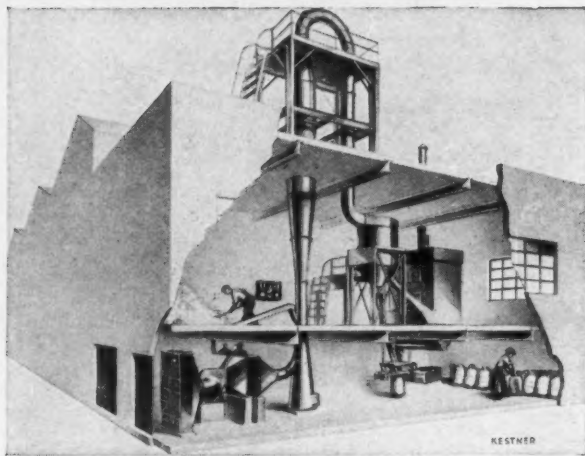
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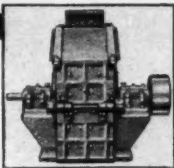
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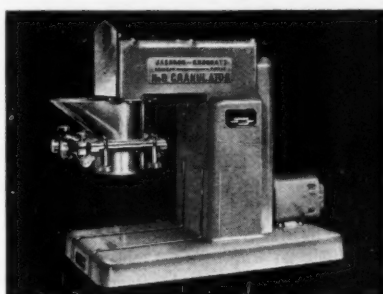
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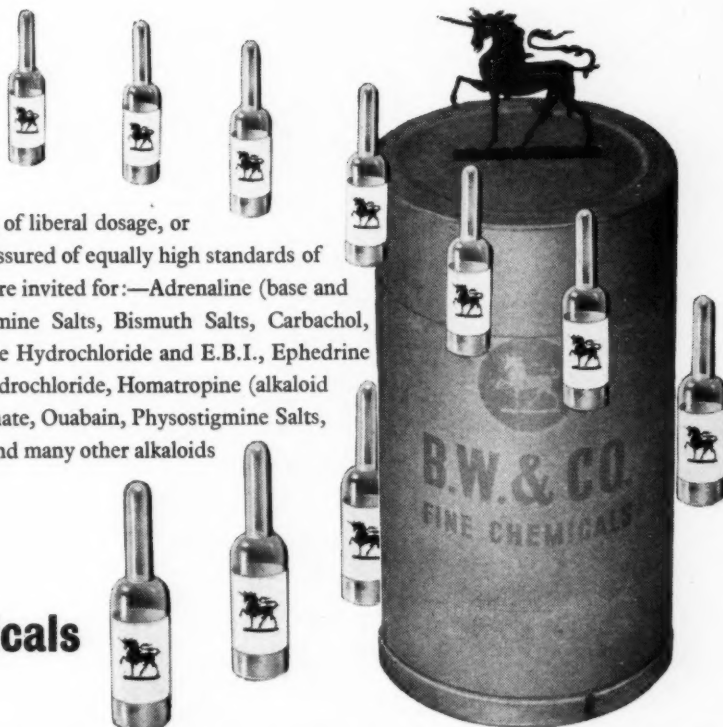
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